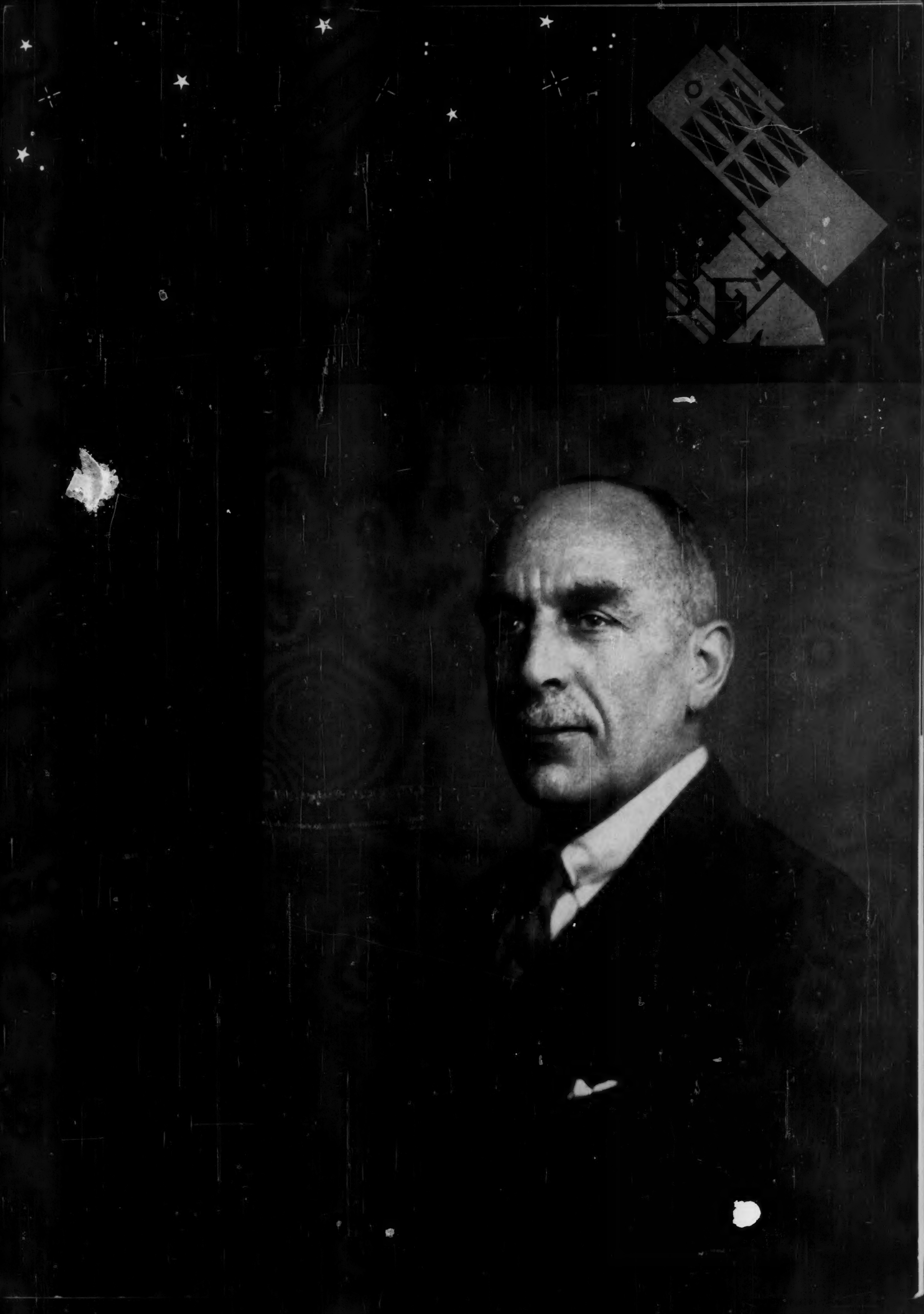

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
JOSEPH ASHBROOK, *Technical Editor*

Vol. XXI, No. 2 FEBRUARY, 1961

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COVER: Sir Harold Spencer Jones, England's tenth Astronomer Royal, who died November 3, 1960, at the age of 70. Photograph copyright by Walter Stoneman, courtesy of the Royal Astronomical Society. (See page 76.)

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Second-class postage paid at Boston, Mass.

Subscription: $5.00 per year in the United States and possessions; $9.00 for two years; $13.00 for three years. To Canada, Mexico, and all countries of the Pan American Postal Union, $6.00 for one year; $11.00 for two years; $16.00 for three years. To all other foreign countries, $7.00 for one year; $13.00 for two years; $19.00 for three years. Canadian and foreign remittances should be made in United States currency. Single copy 50 cents. *Back issues:* November, 1958, to present, 75 cents per copy, $6.00 for 12 issues, postpaid; Vols. I through XVI (November, 1941, to October, 1957), order from Johnson Reprint Corp., 111 Fifth Ave., New York 3, N. Y.

All notices of change of address must be sent one month in advance and accompanied by old and new addresses. When sending your renewal order, or writing in regard to your subscription, your current mailing address must be given. Return our bill form with renewal payment. Circulation manager, Nancy R. Bolton. Office staff: Sarah E. Bulger, Virginia K. Cox, J. Caroline Nason, Mary Silva, John Simmons, Helen B. Sniegiecki, Stacia Strong, Aubrey S. Wheaton, Jr.

Editorial and advertising offices: 49-50-51 Bay State Rd., Cambridge 38, Mass. Assistant editors: Gail B. Carney, advertising; William E. Shawcross, departments; Raymond N. Watts, Jr., features. Art assistant, Willem P. Schrauwen. Advertising rates are listed in STANDARD RATE AND DATA SERVICE, or sent upon request; closing date (except covers) is 20th of second month preceding date of issue. Unsolicited articles and pictures are welcome, but we cannot guarantee immediate attention to them nor their safe return.

The principal articles are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

Dust Cloud Around the Earth

OUR PLANET is surrounded by an enormous dust cloud over 100,000 miles in diameter, thinning out in all directions. The existence of this concentration of tiny particles, suspected in 1958 by D. B. Beard, Lockheed Aircraft Corp., has now been confirmed in detailed studies by Fred L. Whipple of the Harvard and Smithsonian Astrophysical observatories, and by Arthur Hibbs of California Institute of Technology.

Rockets, satellites, and space probes carrying micrometeorite impact counters have supplied the main evidence for this newly discovered envelope of the earth. Most such counters operate like microphones; the impact of a tiny, fast object on a piezoelectric crystal produces an electric impulse.

Last October, Dr. Whipple found that between heights of 100 and 100,000 kilometers the concentration of particles decreases roughly as the 1.4 power of distance from the earth's surface. Somewhat farther out, the cloud blends into the tenuous interplanetary dust that we observe as the zodiacal light. The innermost portion of the dust envelope may contain up to 100,000 times as many particles per unit volume as the interplanetary medium.

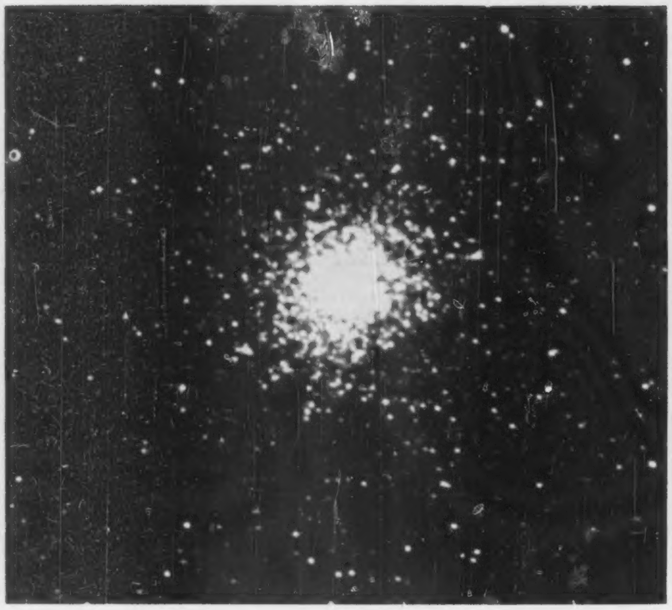
Most of the terrestrial envelope consists of very minute dust grains, around 10^{-9} gram in mass, according to Dr. Whipple. Larger objects seem to be scarcer by a factor of roughly 10 for every tenfold increase in mass.

The origin of the dust cloud is uncertain. Dr. Beard proposed that interplanetary particles are gravitationally attracted by the earth to increase the concentration near it. Another possibility is that the grains acquire large electrical charges in passing through the Van Allen radiation belts, permitting capture by the earth and electrostatic explosion of the material into finer particles.

Both of these mechanisms are inadequate to account for the dust envelope, Dr. Whipple feels. Instead, he now suggests a lunar origin. Meteorites striking the moon's surface should throw up dust and droplets, much of which would escape from the moon, some to pass into temporary orbits around the earth. Rough calculations show that enough material may be supplied in this manner. The higher concentration near the earth would arise from the convergence of orbits and from drag effects.

If the dust cloud is produced this way, it should be flattened toward the moon's orbit plane. This prediction could be tested with artificial satellites.

(Continued on page 81)



At the left is NGC 1866, the brightest of the "blue" globulars in the Large Magellanic Cloud, and at the right is a "red" cluster there, NGC 1978. Blue clusters have their brightest stars of early spectral type, while the red ones have brightest stars of late type. Both pictures are enlarged about eight times from plates of the 60-inch reflector in South Africa. All photographs with this article are courtesy Harvard Observatory unless otherwise credited.

Globular Clusters in the Magellanic Clouds

PAUL W. HODGE, *Harvard College Observatory* and *Smithsonian Astrophysical Observatory*

The Small Magellanic Cloud, photographed with the 32-inch ADH (Baker-Schmidt) telescope of Boyden Observatory, originally operated by Armagh, Dunsink, and Harvard observatories.

NEAREST TO US, and in many respects best observed of all other galaxies, are the Magellanic Clouds. While they are easily visible to the unaided eye, they are too near the south celestial pole to be seen north of the tropics. Named for the explorer Ferdinand Magellan, these objects were reported by early travelers to the Southern Hemisphere. Yet despite their proximity in space, they have presented many unsolved problems.

For almost 50 years, astronomers have been puzzled as to the precise nature of certain objects in the Magellanic Clouds that, as Harlow Shapley pointed out, look just like normal globular clusters. They are large, circular in outline, and heavily populated with stars. In these three respects they differ markedly from open clusters observed in the Clouds, and resemble such well-known globulars of our galaxy as M13 in Hercules and M3 in Canes Venatici.

In his book *Star Clusters* (1930), Shapley lists as globular only two clusters in the Small Cloud (NGC 416 and 419) and

eight in the Large: NGC 1783, 1806, 1831, 1835, 1846, 1856, 1866, and 1978. The brightest of these is NGC 1866, a huge object near the northern edge of the Large Cloud. In addition, he mentions 21 more as possibly being globular.

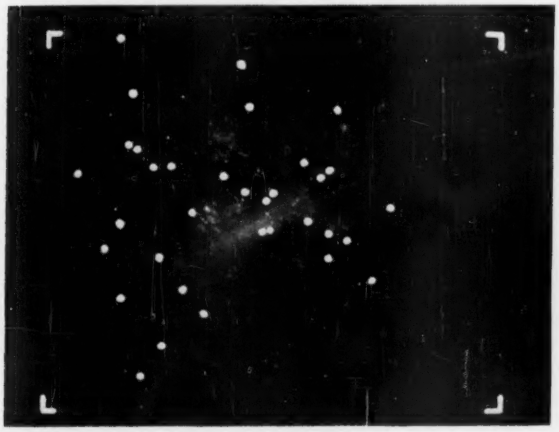
Are all of these distant objects globular clusters? Serious doubts were raised by Annie J. Cannon's spectral studies early in this century. She found that in globulars of the Milky Way system the combined light of all the stars resembled that of a single star of late spectral type. On the other hand, similar integrated-light studies of some of the clusters in the Large and Small Magellanic Clouds gave unexpectedly early spectral types.

About 10 years ago, A. D. Thackeray took photographs in blue and red light of NGC 1866, using Radcliffe Observatory's 74-inch reflector at Pretoria, South Africa. He discovered, to the surprise of astronomers, that the brightest stars were blue, not red as in the case of normal globular clusters. At nearly the same time, Shapley and Virginia McKibben Nail were examining plates of NGC 1866 obtained with the 60-inch reflector at the Boyden station in South Africa. They found in it more than a dozen classical Cepheid variables of three-day period. Since no normal globular contains classical Cepheids, which are generally associated with a galaxy's spiral arms, this result also was surprising. Thus the cluster, though it looks like a globular, contains different sorts of stars and represents an entirely new type of object, unknown so far in our own galaxy.

Are all the Magellanic Cloud clusters that look like globulars of this new type? This question was answered in 1952 by S. Gascoigne and G. Kron, who used telescopes at Mt. Stromlo Observatory, Australia, to measure photoelectrically the colors of globularlike clusters. Of those they observed, about half were blue, including NGC 1866, while the remainder were red, like normal globulars. This led to the names *blue globular* and *red globular,* the former being the newly recognized class of objects.

A year after Gascoigne and Kron's announcement, Thackeray and A. Wesselink, at Radcliffe Observatory, found the first RR Lyrae or cluster-type variables in the Magellanic Clouds. These were located in three red globulars, one of these clusters being in each of the Clouds, and one situated between them. Since these short-period variables and red giant stars are among the most luminous objects in the globular clusters of our galaxy, this proved that these three red clusters were similar. A very recent study by J. B. Alexander of the Large Cloud cluster NGC 2257 has turned up nearly 30 RR Lyrae variables.

Our neighbor galaxy, the Large Magellanic Cloud, contains all kinds of objects familiar in the Milky Way: clusters, nebulae, absorbing dust, and variable stars. It covers an extensive area, as this field picture is nearly seven degrees wide and 8½ degrees high. A small part of its upper right corner is enlarged to 10 times this scale on the next page. The key picture below is about one-fourth the scale of this photograph.

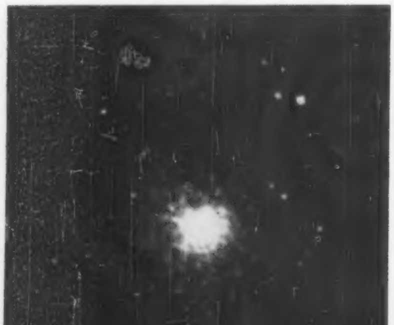


On this photograph of the Large Magellanic Cloud, taken with a Harvard 3-inch camera, Paul W. Hodge has plotted the distribution of red globular clusters. The corner marks indicate the region covered by his survey, an area of 125 square degrees.

During the last two years our knowledge of both the red and blue clusters has increased considerably. H. C. Arp has plotted color-magnitude diagrams for two of the red ones in the Small Cloud, NGC 419 and 361. He found that the general shape of their arrays was like those for normal globulars, which show an almost horizontal giant branch, extending from very red to extremely blue stars, and a nearly vertical subgiant branch that joins the cluster main se-

A portion of an ADH plate, enlarged by the author to a scale of about 0.3 minute per millimeter. NGC 1783, a red globular, is at upper right, while NGC 1818, predominantly blue, is in the lower left. The diffuse nebula at lower right is NGC 1763, also seen in the northwest corner of the picture of the Large Magellanic Cloud on the preceding page.

quence at about spectral class *F*5. However, there were certain differences that led Arp to conclude that these clusters in the Small Cloud might not be of the same age as the ones in our galaxy, or that their member stars might differ in chemical composition from those in Milky Way globulars.



NGC 1856, a blue globular cluster of the Large Magellanic Cloud, enlarged about six times from a plate taken with the 60-inch Rockefeller reflector of Boyden Observatory.

In 1958-59 I used the ADH Baker-Schmidt telescope at the Boyden station to make a complete search for red globular clusters in the Large Cloud. An area of 125 square degrees was covered by plates taken in blue and yellow light. It was possible to distinguish globular from open clusters by a direct comparison of the plates in a blink microscope. In the case of a globular, the blue plate would show a group of nearly equally bright stars just above the plate limit, whereas the yellow one would show a group of stars two or three magnitudes brighter than the threshold.

All of the objects that were possible globulars were further tested by rough measurements of the colors of their stars. A total of 35 clusters were found to have color-magnitude diagrams like those of normal globulars. They ranged from large, bright systems like NGC 1978 to tiny, unpopulous clusters too insignificant for inclusion in the NGC catalogue.

More accurate color-magnitude arrays have since been obtained for four of these clusters by A. R. Sandage and O. J. Eggen, and by myself, with results very similar to Arp's. But all four diagrams differ from those for typical Milky Way globulars, such as are found in the spherical halo around the galactic center. Instead they resemble that for NGC 6356, a globular cluster near the center of the

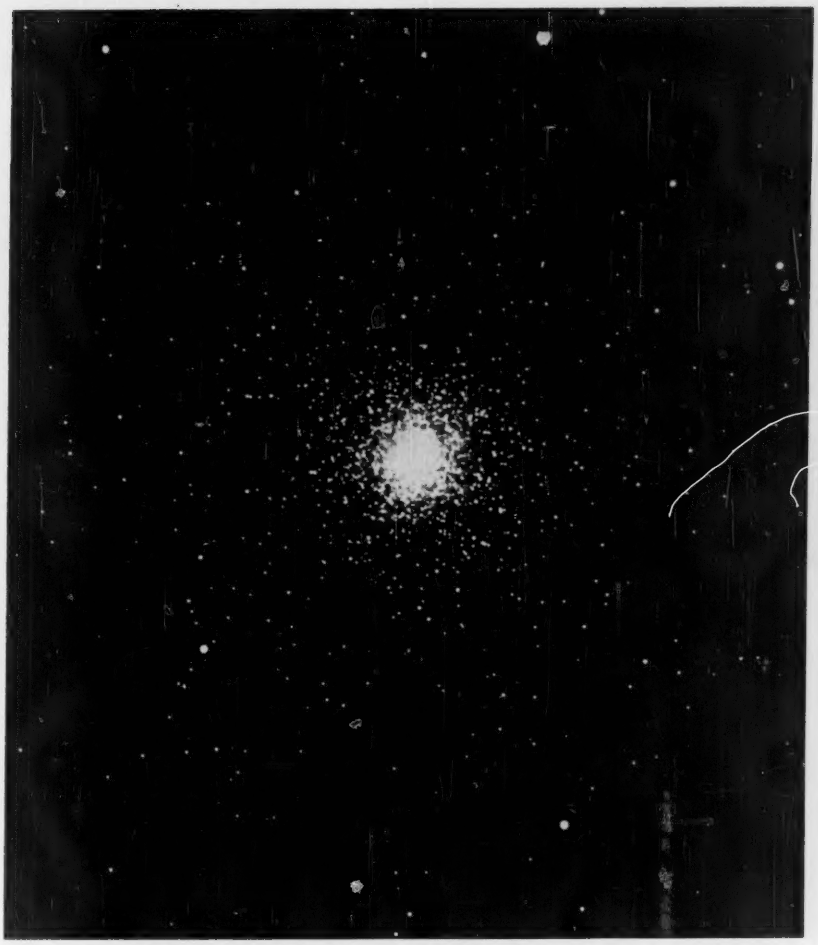
NGC 1846, a red globular cluster in the Large Magellanic Cloud, enlarged about six times from a blue plate.

galactic system, which has a more gently sloping giant branch.

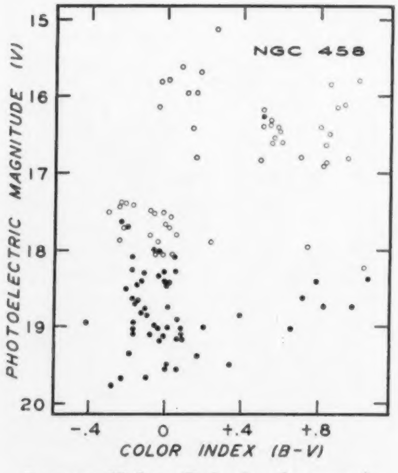
NGC 6356 has been studied at Mount Palomar by Sandage and G. Wallerstein, who find that it probably is richer in heavy elements than are the other Milky Way globular clusters. The chemical composition of the Magellanic Cloud red globulars may be similar.

There is also evidence that the blue globulars have peculiarities in chemical content, making them unlike the open clusters in our Milky Way. Arp's color-magnitude arrays for NGC 458 and 330, two fairly populous clusters of the Small Cloud, are unlike anything with which we are familiar. The main sequences of both resemble those of young open clusters, like the Pleiades or h and Chi Persei. The giant branches, however, lie in entirely different parts of the color-magnitude diagram from those of known open clusters. Arp's explanation is that both NGC 458 and 330 differ in chemical constitution from the open clusters of our Milky Way.

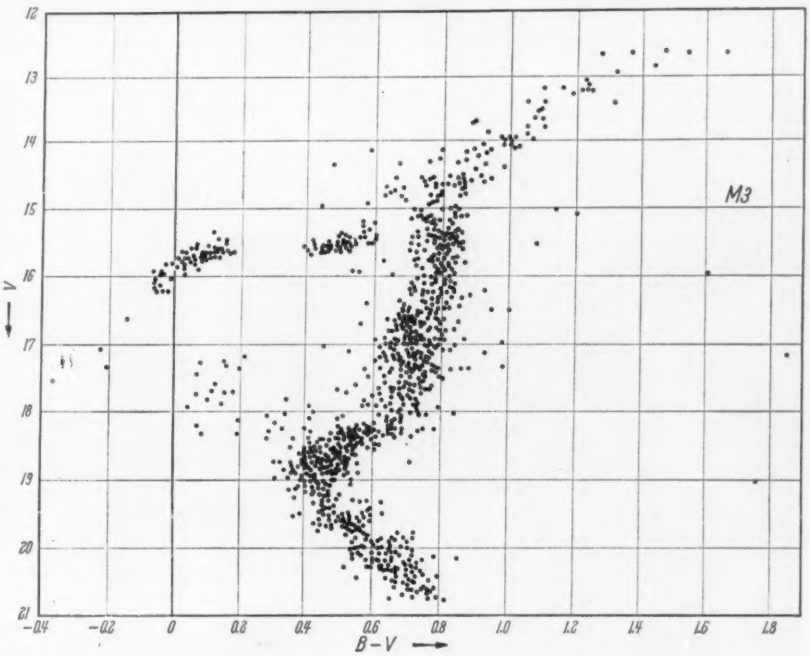
Arp and Sandage found similar results for NGC 1866, the brightest of the two dozen blue globulars I catalogued in the Large Cloud. Could it be possible, as Arp has suggested, that these clusters are poorer in heavy metals than the young clusters of our galaxy? Are the blue clusters simply young globulars? We do not know what the color-magnitude arrays of systems such as M3 or M13 might have been a few billion years ago, when they were only some hundreds of thousands of years old. Some day, however, we may be able to compute complete theoretical evolutionary paths for stars in such objects, and finally solve the riddle of the blue globular clusters in the Magellanic Clouds.



The globular cluster Messier 3, in Canes Venatici, from a photograph taken with the 36-inch Crossley reflector of Lick Observatory in 1900. Its color-magnitude diagram (below) resembles those of red clusters in the Magellanic Clouds, and is quite different from the blue clusters, such as NGC 458. Reproduced from Vol. VIII of Lick Observatory "Publications."



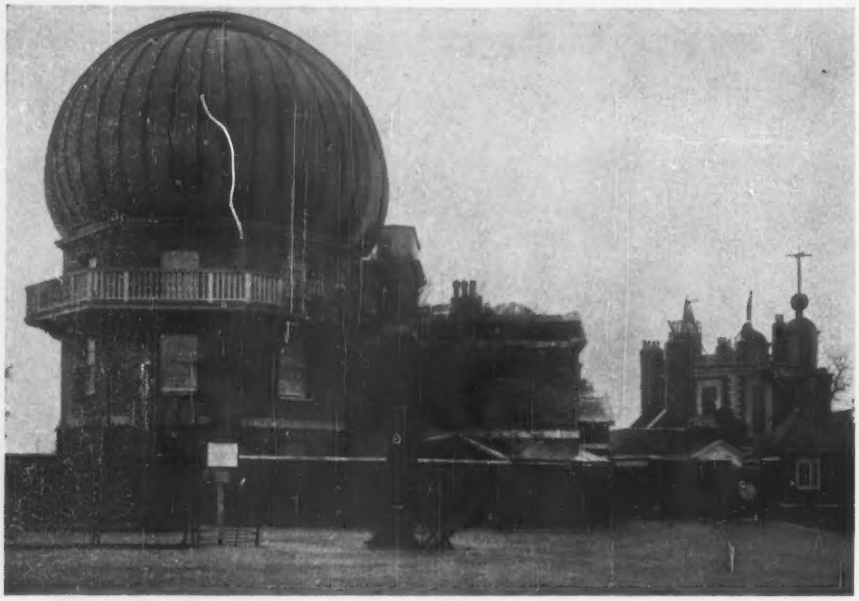
Compare Halton C. Arp's color-magnitude diagram for NGC 458 (above), a blue globular in the Small Cloud, with H. L. Johnson and A. Sandage's plot for M3 at the right. The Arp diagram is adapted from the "Astronomical Journal," while that for M3 is from the "Handbuch der Physik."



Tenth Astronomer Royal

ALAN HUNTER

Royal Greenwich Observatory



Historical buildings at Greenwich, where Sir Harold Spencer Jones began his term as Astronomer Royal, include the unique onion-shaped dome of the 28-inch refractor and the observatory's oldest part, Flamsteed House (right).

WITH the sudden death of Sir Harold Spencer Jones, Great Britain's Astronomer Royal from 1933 to 1955, astronomy has lost a giant. Nobody could direct one of the largest observatories in the world for nearly a quarter of a century without leaving his mark on national astronomy, but Spencer Jones was more than a distinguished British astronomer — he was an international figure whose loss will be felt in many countries other than his own. He had seemed in good health to the end, though some of his colleagues knew that he had more than once been subjected to heart attacks similar to the one that struck him down on the evening of November 3, 1960. He did not survive the night.

Harold Spencer Jones was born on March 29, 1890, in London, where he received his early education at one of the big establishments so misleadingly called public schools in England. From there he went up to Jesus College, Cambridge, where his flair for mathematics and physics soon marked him out from his contemporaries. From this distance in time it seems inevitable that he should have earned the Isaac Newton studentship and the Smith's prize and that, as was common at the time with the most brilliant mathematicians that Cambridge produced, he should have been invited by the Astronomer Royal to take up the post of chief assistant at the Royal Observatory, Greenwich. He accepted Sir Frank Dyson's offer in 1913.

Almost at once the first World War interrupted his astronomical career, but his knowledge of physics was put to good use when he became assistant director of inspection of optical supplies for the Ministry of Munitions. The Royal Arsenal at Woolwich is only a few miles from Greenwich, and it is typical of Spencer Jones' energetic application to any job that the few astronomers remaining at the observatory found themselves testing and adjusting thousands of binoculars called in from the British public for military use.

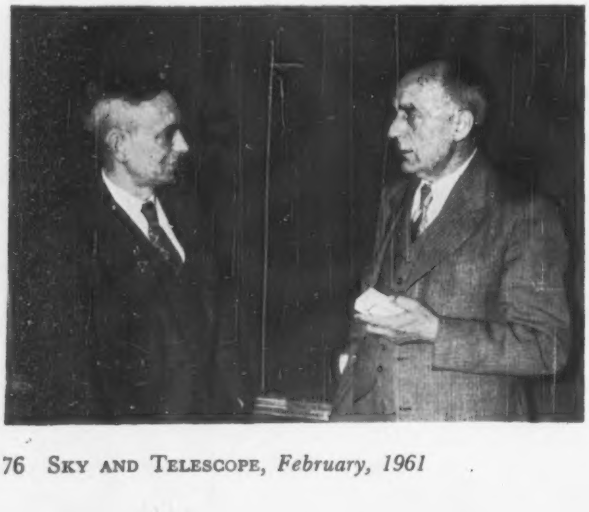
After the war he returned to his astronomical duties, and in 1923, upon the death of S. S. Hough, assumed the post of His Majesty's Astronomer at the Cape of Good Hope. Under Spencer Jones' direction, the output of work at the Cape increased tremendously during the next 10 years. As positional astronomy was his greatest interest, he set to work analyzing the meridian observations that had accumulated, meanwhile encouraging more and more observational activity. Largely as a result of these efforts, meridian astronomy in the Southern Hemisphere now depends almost wholly on the Cape Observatory.

Nor was photographic astrometry forgotten, for it was Spencer Jones who initiated the trigonometric parallax program that is responsible, directly or indirectly, for most of our knowledge of stellar distances in the southern sky. He undertook personally the reduction of the great mass of spectroscopic observations of Nova Pictoris 1925, publishing a memoir of painstaking thoroughness and clarity.

Toward the end of his term of office at the Cape, he initiated the great international campaign for observing the minor planet Eros at its 1931 opposition, the purpose being to redetermine the solar parallax. Organizing this program with administrative skill of a high order, Spencer Jones obtained observations that were quite homogeneous, although they were made at many observatories all over the world, with various instruments and by observers not all of whom were accustomed to such work.

In 1933 Dyson retired from Greenwich, and Spencer Jones returned to England to take his place as Astronomer Royal. Here his earlier experience as chief assistant stood him in good stead. In addition to measuring and reducing the Eros plates, a task that took him and his staff 10 years, he initiated a great expansion in the work of the time department.

Hitherto, the time service had depended on Shortt clocks emitting the precision time signals, and on auxiliary equipment that had been modified and



Sir Harold Spencer Jones, right, talks with Brian O'Brien at the University of Rochester in 1949. During that visit to the United States, the Astronomer Royal obtained from the University of Michigan an unused 98-inch mirror blank for the Isaac Newton telescope of the Royal Observatory.

adapted since the days of the old-fashioned regulators, until modification and adaptation could go no further. The whole equipment of the department was modernized, and within a few years pendulum clocks themselves were superseded by quartz-crystal oscillators. In the application of these to precision timekeeping, Greenwich played a leading role.

Doubtless, it was on his return from the clear skies of South Africa to the murk of suburban London that Spencer Jones conceived the idea of removing the historic observatory to a site more suited to observing the sky. Successive annual reports mention the smoke and bright night skies that hampered work, until by 1939 he felt the time had come to make specific proposals to the British government for total removal from the old location.

With the outbreak of World War II, however, all plans had to be deferred. Through the war years the essential work of the observatory was divided among Greenwich, Edinburgh, and Abinger in Surrey, where a magnetic station already existed and where Spencer Jones completed the reduction of the Eros plates. At the end of hostilities, he searched southeast England for a suitable site, and in 1946 it was announced that the Admiralty had purchased Herstmonceux Castle in Sussex as the future home of the observatory.

Moving a large observatory without interrupting its important services to the nation would tax the ablest administrator. Doing so after a major war, when the national resources were bent to more pressing needs than astronomy, was much more difficult. A measure of the task is the length of time it took to get the necessary building done and the telescopes dismantled. A nucleus of the staff moved to Sussex in 1948; the final links with the Greenwich location were not severed until 10 years later, two years after Spencer Jones had retired.

In the intervening years his responsibilities visibly aged him, but his energies never seemed to slacken, and he found time for visits abroad to advise on astronomical matters. This desire to further many causes distinguished him. That he could simultaneously carry through major astronomical investigations astonished all who were not familiar with his methods of working.

One factor that must have contributed greatly was his facility for setting out in final form not merely tidy computational work — as might perhaps be expected — but textual matter of the highest complexity written with beautiful clarity and requiring no amendments. In the late 1940's he published a popular book, *Life on Other Worlds,* and the third edition of his *General Astronomy* appeared in 1951. His writings were popular with readers and amateur astronomers in both Europe and America.

Honors came thick and fast in the later part of his career. He was elected a fellow of the Royal Society in 1930, knighted in 1943, and created a Knight of the British Empire in 1955. His work on the solar parallax gained him in 1943 the gold medal of the Royal Astronomical Society and a royal medal of the Royal Society. He was awarded the Bruce medal of the Astronomical Society of the Pacific in 1948 and the Rittenhouse medal of the Franklin Institute in 1955. A bewildering list of presidencies includes those of the Royal Astronomical Society (1937-39), the International Astronomical Union (1945-48), and the Institute of Navigation (1947-49). His honorary degrees and foreign memberships of national academies are too numerous to specify.

The former Astronomer Royal's tall, well-proportioned figure and deep voice were well known in scientific circles of all kinds throughout the world. Upon first meeting him, taciturn modesty could be mistaken for standoffishness, but with better acquaintance his warmth of character became apparent. If he seemed to give his friendship to few, he was known as a pleasant companion by many. It is a measure of the man that he will be mourned by many who are not astronomers and by more who were not his compatriots.

Herstmonceux Castle, the present home of the Royal Observatory, seen from the southeast. It was originally built as a medieval residence in 1440. The castle was renovated and the interior converted into library, offices, and the Astronomer Royal's residence. The move from London to this site in southeastern England was instigated by Spencer Jones.

NEWS NOTES

NEW STANDARD OF LENGTH

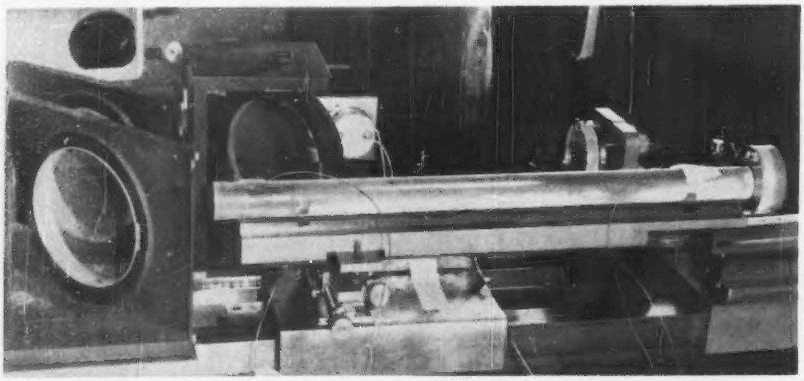
By international agreement, the meter is now defined as exactly 1,650,763.73 wave lengths of the orange spectrum line of krypton-86 gas at 6056 angstroms. The official decision was made October 14, 1960, by the 11th General Conference on Weights and Measures, which was meeting in Paris.

Since 1889, the international standard of length had been the distance between two lines engraved on a platinum-iridium meter bar kept at Paris. Duplicates of this bar were used at the National Bureau of Standards and similar laboratories throughout the world. But these secondaries required repeated recalibrations against the Paris original, and the latter was suspected to be slowly changing. Hence it became desirable to redefine the meter in terms of a natural constant, reproducible with great accuracy in any well-equipped laboratory.

Krypton gas was chosen because its spectrum lines are very narrow and their wave lengths are only slightly affected by surrounding conditions. To get utmost sharpness and stability of the lines, only one of the six isotopes of krypton is used, that with atomic mass 86, and the krypton lamp is cooled with liquid nitrogen to a temperature of 63° Kelvin.

After a suitable Kr-86 lamp had been developed in Germany by E. Engelhard, five different laboratories made precise interferometer determinations of the wave length of the orange line in relation to a quartz bar, whose length was a known fraction of the Paris meter bar. From many such experiments, the wave length of the spectrum line was found to be very close to 1/1,650,763.73 meter. In the 1960 international decision, this factor is adopted as exact, the meter now being defined in terms of the wave length.

For everyday purposes, and in fact in many scientific applications, the meter may be regarded as unchanged. The distance from New York to Washington would be altered by less than three inches, if measured with the old metal standard instead of the wave-length standard. But the newly adopted meter has the advantage for spectroscopists that the angstrom unit is now exactly 10^{-10} meter, which formerly was not strictly true.



Part of the equipment used at the National Bureau of Standards for comparing the length of a material standard with the wave length of the orange krypton line. The comparison object (center) is a quartz bar 50 centimeters long that had previously been calibrated against old standards. Mirrors are fastened in optical contact with the ends of this bar, and the number of wave lengths of krypton light between them measured by interferometer techniques. National Bureau of Standards photograph.

DID A COMET STRIKE THE EARTH IN 1908?

The famous meteorite that fell in central Siberia on June 30, 1908, continues to occupy the attention of Soviet astronomers. Its impact resulted in a tremendous explosion that felled trees to a distance of 20 miles and broke windows 50 miles away.

Writing in the Soviet science magazine *Priroda*, the Moscow meteorite expert E. L. Krinov renews the suggestion that the object striking the earth that June morning was the nucleus of a small comet. Such a nucleus, according to modern views, consists largely of ice and solidified gases, interspersed with particles of meteoric material. Thus the comet hypothesis offers an explanation of why very little meteoritic debris has been recovered at the impact site, even though the extensive damage indicates that the falling mass may have been several hundred tons.

Calculations by I. S. Astapovich further show that the Siberian meteorite originally had a retrograde orbit, moving from east to west around the sun. This would be allowable for a comet, but not for an ordinary meteorite of asteroidal origin, as all the known asteroids have direct orbits.

Many observers in western Europe recorded peculiar twilights and unusually bright nights immediately following the June 30th event. These phenomena are attributed by Dr. Krinov to dust from the tail of the comet entering the earth's atmosphere and scattering sunlight.

IN THE CURRENT JOURNALS

A NEW SCALE OF STELLAR DISTANCES, by O. C. Wilson, *Scientific American*, January, 1961. "For so-called normal giant stars one good width measurement of the H or K [calcium line] reversal gives the intrinsic brightness with an uncertainty of about .3 magnitude (corresponding to an error of 15 per cent in the distance). By using an average of several width measurements the uncertainty can be reduced to .2 magnitude. For dwarf stars the accuracy of the new method proved to be somewhat lower."

PLASMA PHYSICS, by Russell M. Kulsrud, *American Scientist*, December, 1960. "In the past ten years a new field of physics has become important and popular. This field is plasma physics, which deals with the motion of ionized media such as gases in the presence of external forces, generally magnetic fields. . . .

"First, if a magnetic field is present, the plasma is constrained to move along lines of force even though the lines of force may be changing. Second, the plasma has an abundance of charge and will quickly shield out any electric field in the absence of a magnetic field or any component of electric field along the lines of force of a magnetic field. The first property is the one which most often will lead to practical applications and which yields spectacular phenomena in astrophysics."

NEW PUBLIC OBSERVATORY OPENED IN CLEVELAND

One night a week has been set aside for public viewing at the new observatory atop the Cleveland, Ohio, Museum of Natural History at 10600 East Boulevard. It contains a 10½-inch refractor previously located at Western Reserve University and donated by the school to the museum. Built in 1899 by the Warner and Swasey Co., the telescope was completely reconditioned by them as a contribution to the project. A 19-foot motor-driven Astro-Dome shelters the instrument.

Construction of the observatory was made possible by a $50,000 gift from Ralph Mueller, president of Mueller Electric Co., who had previously given the museum funds for its planetarium. Together, these facilities will be known as the Ralph Mueller Planetarium and Observatory.

The observatory is also available to students and faculty at Western Reserve and Case Institute of Technology for instruction and research.

Sixteenth-Century Cosmographer

Rufus Suter

EVERY rocket flight beyond the moon proves once again that the solid transparent spheres, believed by Aristotle and schoolmen of the Middle Ages to carry heavenly bodies around the earth, do not exist. If they did, Pioneer V would have smashed against the nearest, the sphere in which the moon was supposed to be embedded, much as a hurled light bulb might shatter against a great plate-glass window.

Mankind did not wait, of course, for this direct experimental evidence to refute the medieval spheres. Nevertheless, when we recall that only about a dozen generations ago scholars in all the universities of Europe still accepted the crystalline spheres as scientific fact, we may be impressed by how recent our present-day picture of the cosmos really is.

Who were the first men to reach, through sheer reason, without the clinching argument of actual experiment, the correct conclusion that the spheres do not exist? Copernicus, William Gilbert of Colchester, Galileo, and Kepler were among the first, for the spheres are inconsistent with the heliocentric system. But during the age of these great scientists there lived another man who smashed the spheres effectively, though he was not an astronaut, nor a scientist at all.

This man was Giordano Bruno (1548-1600), born at Nola, near Naples, Italy. His conception of the universe, deduced from a highly speculative theological system, happens to resemble our 20th-century model closely enough to astonish us. A few quotations from his works (as translated by Dorothea Waley Singer in *Giordano Bruno: His Life and Thought*, Henry Schuman, New York, 1950) may show the pertinence of his cosmological view. For instance, does not the following sound as if it were written by a modern poet with an interest in science?

"[The whole universe] then is one, the heaven, the immensity of embosoming space, the universal envelope, the ethereal region through which the whole hath course and motion. Innumerable celestial bodies, stars, globes, suns and earths may be sensibly perceived therein by us and an infinite number of them may be inferred by our own reason. The universe, immense and infinite, is the complex of this [vast] space and of all the bodies contained therein."

Opposed to this conception of the universe was the Aristotelian and scholastic model still authoritative in Bruno's day. He criticized it in words which could not be better chosen by a modern scientist writing in a popular vein.

"As soon as we have recognized that the apparent world-motion is caused by the real diurnal motion of our earth (which happeneth similarly to other similar stars), no argument will constrain us to accept the vulgar opinion that the stars are equidistant from us, that they are as though nailed and fixed in an eighth sphere; and no persuasion will hinder us from knowing that the differences are innumerable in the length of the radii of the distances from us of these innumerable stars. We shall understand that the orbs and spheres of the universe are not disposed one beyond another, each smaller unit being contained within a greater — as, for example, the infoldings of an onion."

The "eighth sphere" was, in Aristotle's cosmology, the outermost one, in which the stars were fixed. The rotation of this sphere kept in motion all the other spheres inside it, containing the various planets, the sun, and moon. The eighth sphere was, accordingly, the limit of the physical universe. When Bruno rejected it in favor of infinite space peopled by an infinite number of stars and planets, he went beyond the ideas of Copernicus, Galileo, and even the imaginative Kepler.

Giordano Bruno, the 16th-century Italian philosopher who envisioned an infinite universe of countless worlds. This statue stands in the Campo de' Fiori, Rome, upon the spot where Bruno was burned at the stake for heresy, on February 17, 1600.

With the general outline of Bruno's universe in mind, we turn to a passage setting forth particular details that are familiarly accepted today. "Why then do we not see the other bright bodies which are earths circling around the bright bodies which are suns? . . . The reason is that we discern only the largest suns, immense bodies." (Bruno has already explained how far away these suns are.) "But we do not discern the earths because, being much smaller, they are invisible to us. Similarly it is not impossible that other earths revolve around our sun and are invisible to us on account either of greater distance or of smaller size. . . ." This last speculation is remarkable, for in the centuries since its author's death Uranus, Neptune, Pluto, and a host of planetoids have been discovered.

Bruno understood several elemental facts of modern astronomy: The stars and the sun are similar bodies shining by their own light, while planets, including the earth, shine by reflected light. The earth shines by light reflected from our star, the sun; if planets exist in other solar systems, they reflect the light of their suns.

He saw clearly one phenomenon that has yet to be fully experienced by astronauts. There was no absolute downward for Bruno, as there was in the limited, earth-centered cosmology of Aristotle and the medieval schoolmen. For them it was an indisputable scientific fact that there is, and can be, but one downward, and that is toward the center of the immobile earth. Anything that is heavy would have a universal cosmic tendency to move downward in this exclusive sense. Bruno saw that downward is a relative term. What is downward for us, from our point of view on the earth, may be upward for somebody on the moon. And a heavy body in the vicinity of the moon, the sun, or any planet or star, might naturally tend to move toward the center of one of those bodies.

The absolute qualitative distinction which the Aristotelians and the scholastics drew between heavy and light Bruno saw to be only a prejudice. He knew that bodies have "weight," but that this was not due to any cosmical urge directed exclusively toward the center of the earth. He seems to have been struggling to reach the concept of mass, so important in the development of modern physics.

It is rather odd that Bruno should have hit upon so many ideas congenial to the world view of our century, especially when he was not a mathematician, observer, or experimenter. According to Dorothea Singer his place in the history of thought is not in the scientific tradition of such reforming astronomers as Copernicus or Galileo. It is rather that of a mystic philosopher with "certain remarkable premonitions of modern physical thought."

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 107th meeting of the American Astronomical Society at New York City, December 28-31, 1960. Technical abstracts will appear in the Astronomical Journal.

Hot Spots on the Moon

The 60-inch Mount Wilson reflector is being used by two Boeing Airplane Co. scientists, J. M. Saari and R. W. Shorthill, for detailed charting of temperatures in different regions on the moon. Infrared radiation from a 10-mile-diameter lunar area is detected by a thermistor at the Newtonian focus of the telescope. From repeated scans, isothermal contour maps are constructed.

Observations of this kind during the total lunar eclipse on September 5, 1960, showed that the floors of some rayed craters (Tycho, Copernicus, Aristarchus, and Kepler) did not cool off as much as the rest of the moon, remaining about 40 degrees centigrade warmer than their surroundings. Dr. Shorthill had observed the same effect for the first three craters at the March 13, 1960, eclipse.

At Lowell Observatory, W. M. Sinton measured the 8.8-micron infrared radiation from Tycho during the September eclipse with a pyrometer attached to the 42-inch reflector. The environs of Tycho cooled off about 50 degrees more than the crater itself. This can be explained, Dr. Sinton points out in Lowell Observatory *Bulletin* 108, if the surroundings are covered by thick dust and the crater floor by a thinner layer, perhaps 0.3 millimeter thick.

Period Changes in RR Lyrae Variable Stars

The typical RR Lyrae variable is a star pulsating with great regularity in a cycle of a few hours. Its period can be determined with extreme precision – sometimes to one part in 10^7.

The evolutionary development of an RR Lyrae star produces a minute progressive change in period and may, therefore, be detected by observation. No other physical property of an individual star can be measured with similar accuracy; luminosities, temperatures, and radii are so much more roughly known that there is no hope of recognizing their trends.

However, many individual RR Lyrae stars show small erratic alterations in period. The best test for a progressive lengthening or shortening is from the average of many of these variables, for example those in a rich globular cluster. Such a test was applied 30 years ago to the great southern globular Omega Centauri by the Dutch astronomer W. C. Martin.

This study has recently been continued for 32 RR Lyrae variables in Omega Centauri by Emilia Belserene of Rutherfurd Observatory, Columbia University. The period changes were deduced by comparing photographic observations made by Harvard's S. I. Bailey in 1896, Martin in 1931-35, and by herself in 1947 and 1957.

At New York City, Frank J. Kerr reported Australian radio astronomy developments to the joint meeting of the American Astronomical Society and Section D of the American Association for the Advancement of Science. Photograph by Mrs. William H. Glenn.

The Columbia astronomer found that the 32 stars, averaged together, show a well-marked progressive lengthening in period, at a rate of about 0.15 day per million years. She feels confident that the trend is real, and not the result of chance. Martin, too, had found that increasing periods predominated, but his result was much less certain.

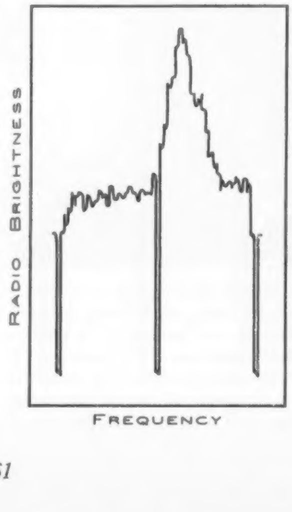
Australian Radio Observations of the Magellanic Clouds

A typical radio astronomer spends most of his time analyzing enormous lengths of paper strips on which a pen recorder has traced his observations. A successful test of new digitizing equipment to avoid this drudgery was described by Frank J. Kerr, of the radiophysics laboratory, Commonwealth Scientific and Industrial Research Organization, Sydney, Australia. This test was a radio survey of the Magellanic Clouds, yielding important new information concerning these two nearby galaxies.

The project was carried out by Dr. Kerr, J. V. Hindman, R. X. McGee, and A. W. L. Carter. It was a pilot test of techniques to be used with CSIRO's 210-foot radio telescope (SKY AND TELESCOPE, October, 1959, page 666) that is now within a few months of completion. They used a smaller antenna with a beam width of 2.2 degrees, and a 48-channel receiver, to make simultaneous measurements of radio brightness at closely spaced frequencies within the profile of the 21-cm. hydrogen emission line.

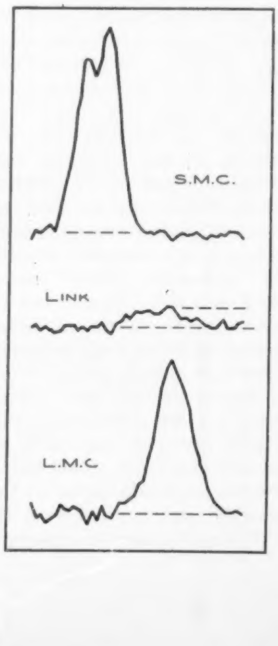
All but the two outermost channels were spaced at intervals corresponding to Doppler shifts of seven kilometers per second. In order to match the apparent average recession of the Magellanic Clouds, the center frequency of the receiver was crystal-controlled at the value equivalent to a velocity of +217 kilometers per second. The output of the channels was recorded, at the rate of one profile every two minutes, on a conventional Speedomax chart (as shown here) and on punched paper tape.

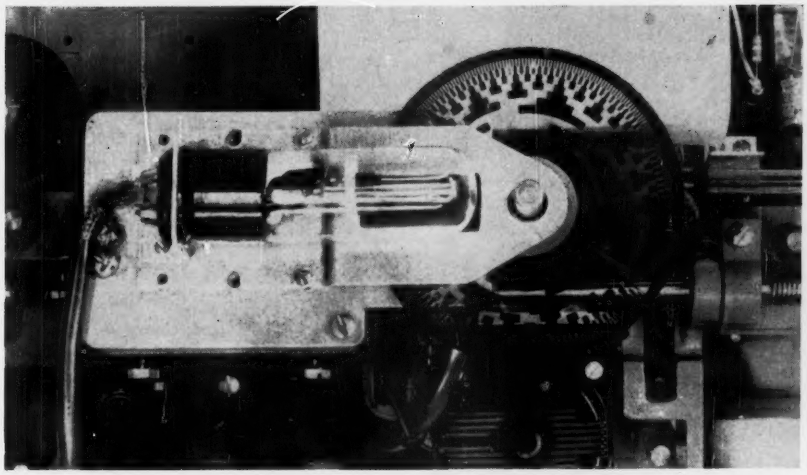
To prepare data for the tape, a 10-digit cyclic binary coding disk was attached to the potentiometer shaft of the chart recorder, and light from a flashing lamp was projected through the disk onto a bank of 10 phototransistors. A master clock and program unit controlled the readout,



Left: A typical hydrogen-line profile on the Speedomax chart is made from the outputs of 48 channels. A zero-point reading is taken every minute.

Right: Computed averages of several profiles of each Cloud and the link. The peak intensity of the link was only about 2° Kelvin. Horizontal displacement is due to differing radial velocities.





The heart of the equipment for automatically recording radio astronomy observations is the coding wheel, through which a flashing light activates phototransistors. The wheel converts angular motion of the pen recorder's potentiometer shaft into a digitized code which is punched on paper tape for subsequent analysis in a large computer. Photograph courtesy Commonwealth Scientific and Industrial Research Organization.

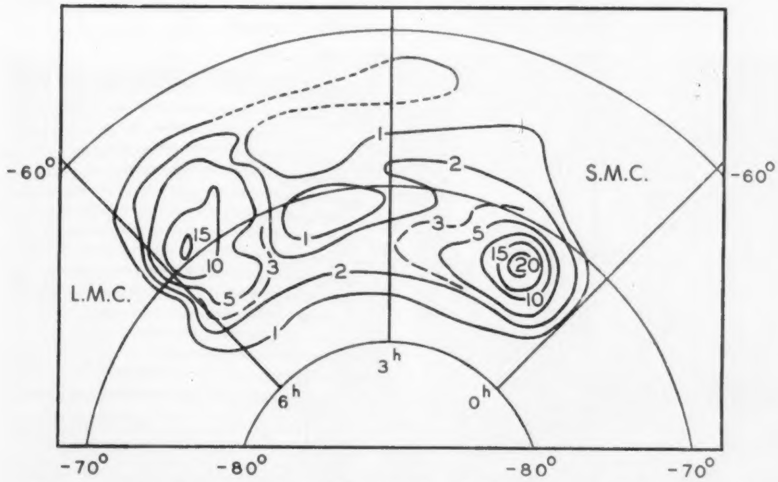
selection of the channels, and other details of the recording operation.

Fifty-three separate items of information were read into each profile block during the two-minute recording period. These included a start and finish symbol, 48 channel intensities, two checking symbols, and the sidereal time. This digital information was punched on the paper tape, each of the 53 pieces of data occupying two characters on the tape. Ten inches of tape were required for each profile recorded. The tapes were processed in the SILLIAC computer of the University of Sydney. The computer automatically corrected for the slope of the base line and the gain differences between channels.

The observations were made at about 6,000 regularly spaced positions over a large area around both Clouds, extending in right ascension from $22^h 30^m$ to $8^h 30^m$, and from $-60°$ to $-80°$ in declination.

One major discovery is that a bridge of tenuous hydrogen gas links the Large and Small Clouds between declinations $-72°$ and $-76°$. This feature had not been found in a 1954 radio survey of the same region by Dr. Kerr and his coworkers. Its detection was made possible by improved instrument sensitivity, and by the more detailed analysis feasible when data are automatically processed.

The new link and another important property of the Magellanic Clouds are shown on the accompanying radio map. The latter is the "steepness" of the eastern edge of the Large Cloud and the western edge of the Small, indicated by the crowding together of the radio-brightness contour lines. One of the first tasks of the 210-foot telescope will be to chart these edges with high resolving power, in order to locate them more accurately and tell how sharp they actually are.



This chart of the area of the Magellanic Clouds gives preliminary results of the survey with digitizing equipment and coded tapes. The grid shows a few lines of right ascension and declination, and the contours are in units of integrated radio brightness at a wave length of 21 centimeters. In addition to the link or bridge between the Clouds, the diagram shows the abrupt intensity decrease at their outer edges. CSIRO chart.

In agreement with the 1954 survey, the total amount of neutral hydrogen in the two Clouds was found to equal one billion solar masses. The new observations have not been fully analyzed from the viewpoint of the Doppler shifts caused by line-of-sight velocities. It is already known that both Clouds are rotating; this raises interesting dynamical problems regarding the motions in the link between them.

Dr. Kerr characterized the Large and Small Magellanic Clouds as forming "a single system, sharply bounded, but well joined in between."

DUST CLOUD AROUND THE EARTH

(Continued from page 71)

At the December meeting of the American Astronautical Society, S. F. Singer of the University of Maryland presented a theoretical model of the inner portions of the dust envelope. The earth's gravitation should produce a peak concentration of the larger dust grains at a height of about 1,000 kilometers.

Smaller particles, however, will have their distribution profoundly influenced by electrical drag forces and by solar radiation pressure. Dr. Singer has calculated these effects, finding a relatively dense dust belt about 6,000 kilometers above sea level. Particles below this height will be negatively charged, those above it positively. The Maryland scientist suggests this pattern may markedly affect the Van Allen belts.

"ELEMENTS IN ASTROMECHANICS"

Under this title, Dr. Peter van de Kamp, Sproul Observatory, has just completed a series of six semitechnical articles in the *Journal* of the Royal Astronomical Society of Canada (Vol. 54, Nos. 1-6, 1960). The six parts are entitled:

I. The Kinematics of Plane Curvilinear Motion and the Geometry of Conic Sections.

II. The Laws of Kepler and Newton's Law of Gravitation.

III. The Two-Body Problem; Orbital Velocity, Size and Shape of Orbits.

IV. Keplerian Motion. The Time Element in Orbits.

V. Energy Relations in Orbits. Elements of Space Flight.

VI. Analysis of Double Star Orbits. Stellar Masses and Unseen Companions.

A limited number of reprints of this series are available to those interested in this field. Requests should be addressed to Dr. Peter van de Kamp, Sproul Observatory, Swarthmore College, Swarthmore, Pa.

When Patrick Moore took this picture last October, work was nearly completed on the dome for the new 102-inch reflector at the Crimean Astrophysical Observatory. Photographs with this article were supplied by the author.

A Note on the Large Russian Reflectors

PATRICK MOORE

UP TO NOW most of the world's greatest telescopes have been set up in the United States. Europe has lagged far behind, with no large reflector comparable with those at Palomar, Lick, or Mount Wilson. The 98-inch instrument planned for the Royal Greenwich Observatory, at Herstmonceux in England, is still a long way from completion.

However, as I found during a recent visit to observatories in the Soviet Union, telescope construction is advancing there.

Probably the best-known Russian observatory is Pulkovo, close to Leningrad. It has a long and honorable history, although the present equipment is almost entirely new (see SKY AND TELESCOPE, November, 1954, page 4), for the old observatory was completely destroyed by German shelling during World War II. Unfortunately, the climate of the Leningrad district is far from favorable, and it would be inadvisable to erect a large reflector there. Therefore, Pulkovo astronomers have also been observing in the Crimea, as conditions near the Black Sea are much better.

For some time, the Crimean Astrophysical Observatory, a few miles from Simferopol, has possessed a Zeiss 50-inch reflector (October, 1955, page 500). The telescope's main function is spectrographic work on stars, but it has also been used for lunar and planetary studies, mainly by N. A. Kozyrev. This was the instrument with which Kozyrev observed a disturbance inside the lunar crater Alphonsus on November 3, 1958.

Close beside the dome of the 50-inch is that of the new 102-inch reflector, the biggest telescope in Europe and third largest in the world. When I visited the Crimea in October, 1960, construction of the dome was not quite finished, and scaffolding was in evidence. By now the 102-inch is in operation. There is nothing revolutionary about its design, but both the optical and mechanical parts have been made entirely in the U. S. S. R. This instrument will be used chiefly for investigations of stars and galaxies, but Kozyrev and others will also employ it for the moon and planets.

The next step is to be the construction of an even larger reflector, with a mirror 236 inches across. To produce optics of this size is a truly Herculean task, as will be appreciated by anyone who has read some history of the Hale 200-inch at Palomar. However, the project is well under way.

Under the direction of B. Ioannisiani, the designs have already been prepared at the Leningrad Optical and Mechanical Works, and have been approved by its technical council. The total weight of the moving parts of the telescope will be about 540 tons.

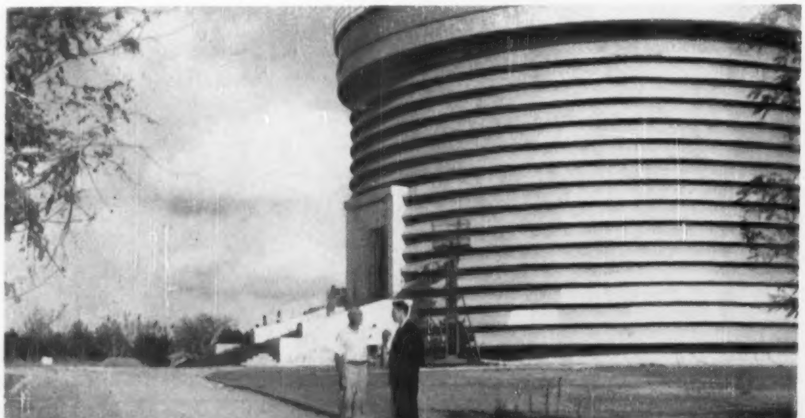
It is still too early to say when this huge instrument will be ready. One tentative estimate gives 1966-67, but others are more conservative, allowing until 1970 or later.

The choice of a site is clearly all-important. To study this problem, a special commission has been formed by the Astronomical Council of the U. S. S. R. Academy of Sciences, under the chairmanship of N. Kucherov. A new laboratory is being set up at Pulkovo to act as a center for site-testing research.

Expeditions from Pulkovo have been sent to various parts of the Soviet Union, including the Caucasus Mountains, the Sea of Azov, Lake Issyk-Kul and the Karakorum desert in central Asia, and the Pacific coast.

No definite decision has been announced, but it is probable that the 236-inch will not be set up in the Crimea. One likely location is near the science center of Novosibirsk, in the general region of Omsk, Siberia. Dr. Kucherov himself has traveled there to study the observing conditions.

Because so much work remains to be done on the telescope itself, there is no immediate urgency to decide upon the site. Further developments will be awaited with keen interest all over the world, for the 236-inch reflector, when completed, should play an important role in astronomical research.



Among the many Soviet astronomers that the author met during his trip was N. A. Kozyrev (left), an expert in lunar and planetary research. They are standing near the entrance to the dome of the 102-inch reflector.

OBSERVING THE SATELLITES

Discoverers XVIII and XIX

WITHIN a two-week span in December, 1960, two Discoverer satellites with different purposes were successfully launched into near-polar orbits from Vandenberg Air Force Base, California. In both firings the second stage was the new Agena B vehicle, described on page 13 last month, but in several important respects the two launchings differed from each other, and from earlier Air Force shots.

Discoverer XVIII rose from the ground on December 7th at 20:21:00 Universal time, boosted by an improved Rocketdyne motor, "Block II," in the Douglas-built first stage. This engine provided a thrust of 165,000 pounds, instead of the 150,000 of the earlier Block I. The greater thrust gave the 58-ton fully loaded rocket an acceleration of 13 feet per second each second, instead of nine. A major advantage is that the missile's fuel supply is used more rapidly; hence less work needs to be spent in lifting fuel against gravity. This saving allows either carrying a heavier payload, or reaching a higher final speed and larger orbit.

After burnout of the Agena B, the 2,100-pound second stage (including the 300-pound re-entry capsule) began traveling around the earth in an orbit inclined 81.48 degrees to the equator. It passed through perigee every 93.62 minutes. This new artificial satellite, 1960σ, initially rose 420 miles above the earth's surface at apogee, and descended to 143 at perigee, according to data from Space Track.

Most earlier Discoverers, on the first revolution, reached apogee as they traveled northward over latitude 17° south, but for 1960σ this was 2° south. Thus the recovery package, with its radiation-detecting experiments, reached only the lower region of the inner Van Allen belt, which is farthest above earth near the equator.

The re-entry capsule carried several dozen physical experiments and biomedical specimens for testing radiation effects. Photographic film packs sensitive to neutrons, X-rays, and gamma rays were included, together with nuclear track plates and radiation dosimeters. Cultures of living human tissues of many kinds, human proteins, algae, and spore preparations were provided by the Air Force's School of Aviation Medicine in Texas.

That school's biologists have recently announced important findings from similar specimens recovered from Discoverer XVII, which orbited during an intense solar flare. Specimens shielded only by the aluminum skin of the vehicle suffered less damage than those covered by heavy metals. Evidently, solar protons generated lethal X-rays when they collided with nuclei of lead or gold. Also there was a bizarre effect of the space environment on living cells: a profound metabolic disturbance, that seemed at least partially reversible in the laboratory afterward.

The materials in the capsule of Discoverer XVIII spent a longer time in orbit than any other recovered specimens. The re-entry was not commanded until the 48th revolution, on December 10th, shortly after 23:10 UT. This was the fourth package recovered in this series, and the third time an Air Force plane snatched the falling parachute in mid-air. The pilot, Capt. Gene W. Jones of the 6593rd Test Squadron, had also taken part in capturing the previous payload.

Discoverer XIX, the 13th shot of the series to attain orbit, started upward at 20:36:51 UT on December 20th, boosted by a Thor equipped with a Block I motor. Unlike all earlier Discoverers, this one had no re-entry capsule. Instead, its Agena B provided a platform with controlled orientation, for testing infrared observing techniques.

The earth and its atmosphere radiate an ever-changing pattern of infrared energy. It is hoped that future Midas satellites will be able to detect against this background the rising column of hot exhaust gases from an ascending rocket. Discoverer XIX's payload was planned to contribute design information for the Midas system. During the five days its power supply lasted, measurements were telemetered to ground stations that included Vandenberg Air Force Base; Kodiak Island, Alaska; Kaena Point, Hawaii; and New Boston, New Hampshire. The last of these stations received the final signal from the satellite's radio.

This latest Discoverer, 1960τ, initially had apogee and perigee heights of 394 and 129 miles, as it circled the earth with an anomalistic period of 92.94 minutes. The inclination of its orbital plane was 83.40 degrees.

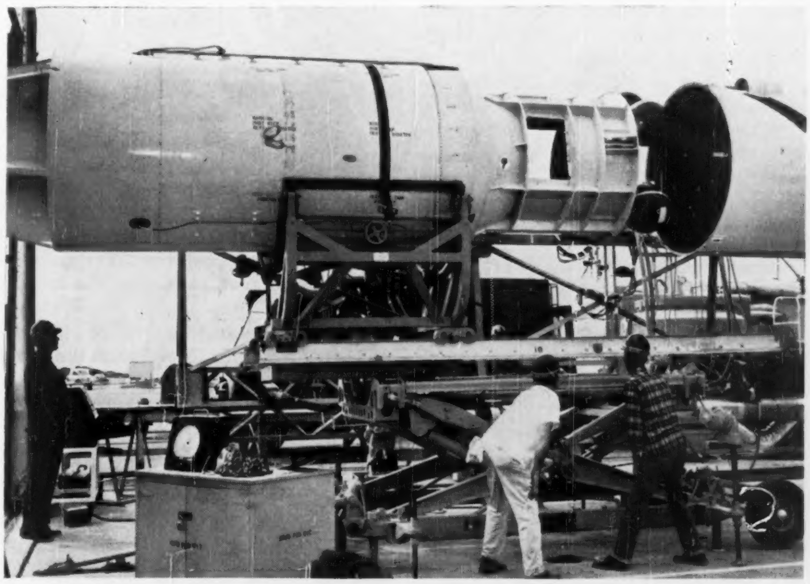
WWV Broadcasts and Satellite Observations

ALL of the methods for tracking the many artificial satellites now circling the earth require a knowledge of the precise time at which each observation is made. Visual or photographic measurements of the direction of a satellite from the observing site, radar determinations of distance, radio tracking of satellites having active transmitters — all depend on timing.

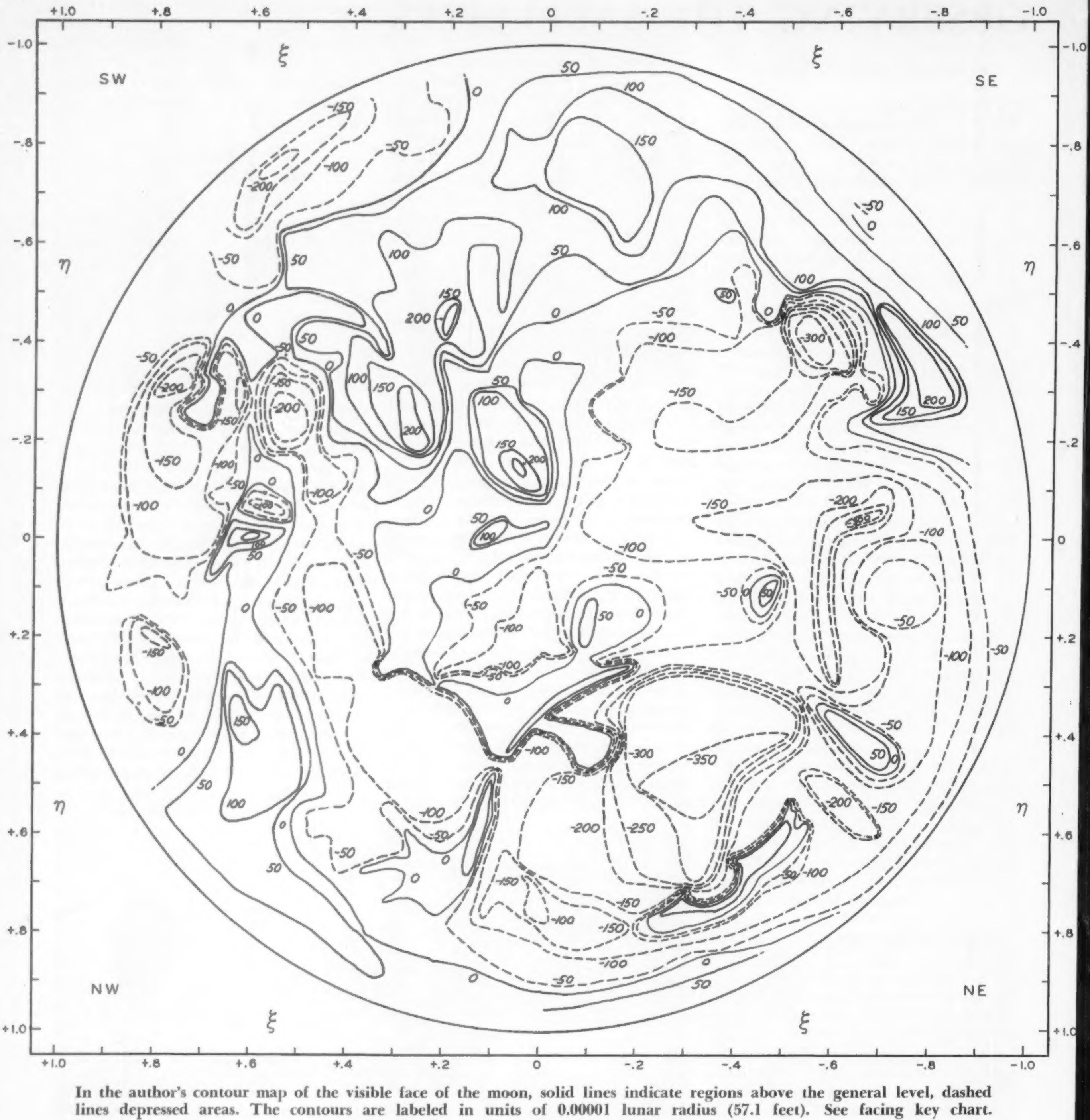
For ideal uniformity, every satellite observation from any part of the world ought to be timed by the same clock. Practically, most great nations transmit the indications of a master timekeeper by short-wave radio signals, which are received by the individual tracking stations. The clock at a station serves only an intermediate role, linking the observations with the radio time signals. At a major installation, this clock is usually a crystal-controlled electronic oscillator, whose indications are recorded simultaneously with the satellite observations.

Since the radio time signals have many other applications in science and industry, the British and American government agencies responsible for them undertook a co-operative program, about a year ago, for co-ordinating the transmissions from stations GBR and MSF at Rugby, Eng-

(Continued on page 91)



Technicians at the Vandenberg Air Force Base, California, check the fitting of a dummy Agena B to the Thor booster rocket. The new Agena is longer and heavier than the A model, and required careful matching to the existing first stage. Official U. S. Air Force photograph.



In the author's contour map of the visible face of the moon, solid lines indicate regions above the general level, dashed lines depressed areas. The contours are labeled in units of 0.00001 lunar radius (57.1 feet). See facing key chart.

A Lunar Contour Map

RALPH B. BALDWIN

It is clearly apparent, even to the naked eye, that the moon is not a smooth and perfect sphere. The terminator, or boundary between the sunlit and dark parts of the disk, shows large irregularities, and these must be caused by real differences in height of various portions of the lunar surface.

Several astronomers have attempted to determine these variations in height by measuring the deformation of the terminator, but without much success. The observations are extremely difficult to make accurately, for they usually refer to areas where the sun's rays strike the moon

In this simplified version of Ralph Baldwin's chart, only the +100 and the −100 contours are drawn (the latter dotted), and the locations of the larger "seas" are shaded. Numbers mark these maria: 1, Australe; 2, Foecunditatis; 3, Crisium; 4, Nectaris; 5, Tranquillitatis; 6, Serenitatis; 7, Vaporum; 8, Imbrium; 9, Nubium; 10, Humorum. Also, 11 is Oceanus Procellarum. Mare Humorum is a particularly deep basin, with a large plateau just to the east (right), as the facing map shows in more detail.

tangentially, so the sunlit portion fades out gradually. Telescopic measures are affected by individual bias, and those on pictures by photographic effects as well. No satisfactory contour maps of the moon have been made from terminator studies.

A second method may be used, taking advantage of the moon's librations. At different times, we see the lunar globe as if it had turned through some 14 degrees. The resulting variation in the apparent direction of lunar features allows height determinations to be made on the stereoscopic principle.

In theory, if the moon were spherical, we could measure the positions of lunar formations on one photograph, and from these positions we could predict exactly where such formations would appear on photographs taken at different librations. The displacement of an object from its predicted co-ordinates on a second picture depends on the height of the object above or below a mean sphere.

By this procedure, the German astronomer J. Franz in 1899 prepared a very rough contour map from 55 points. In 1958 at Vienna University Observatory, G. Schrutka-Rechtenstamm recalculated measurements by Franz of 150 lunar features, and in collaboration with J. Hopmann published a somewhat better chart. No other contour maps based on the stereoscopic principle are available.

In September, 1960, I completed the accompanying contour map of the moon, from an extensive series of measures of 696 points on five photographs taken with Lick Observatory's 36-inch refractor. The co-ordinates were determined with a precision measuring engine at Dearborn Observatory of Northwestern University. An accuracy approaching that of stellar parallax work is needed, but the tiny craters involved are by no means as sharp as stellar images. They range from about one to 10 miles in diameter.

The probable error for a single determination of height turned out to be ±2,270 feet, or about two-fifths of a mile. This is considerably smaller than the six-mile range of heights found for the surface at the positions of these craters. Hence the map should be reasonably reliable. The contour lines are labeled in units of 10^{-5} lunar radius, which corresponds to 57.1 feet. Thus, the difference in elevation is about half a mile between neighboring contour lines, for they are drawn for 50-unit intervals.

The map shows several facts clearly. All of the great maria (indicated by shading in the key chart) are depressed areas. The regions presumed to be formed by asteroidal impacts — Mare Imbrium, Mare Humorum, Mare Crisium, Mare Nectaris, and Mare Serenitatis — are very low. Also, the shelf around Mare Nectaris, inside the Altai Mountains, is slightly depressed. Oceanus Procellarum is low and variable in depth.

In the highlands of the southwest quadrant of the moon, there is evidence of a rise in the surface from the limb toward the center. Also in this region, there is an extensive low area near Mare Australe.

Another noteworthy property is that in most directions the surface slopes down toward the dark areas for at least 100 miles, the descending gradient continuing out onto the maria.

Full details on this project will be given in my forthcoming book on the moon, to be published by the University of Chicago Press.

UNUSUAL NEW STAR IN M31

Although about 26 novae appear each year in the great Andromeda galaxy, according to Halton C. Arp (Sky and Telescope, July, 1956, page 394), most are very faint objects, seldom becoming brighter than 16th magnitude. Last fall, however, an exceptionally bright M31 nova was discovered by L. Rosino, Asiago Observatory, Italy.

The new object appears on seven photographs taken with the Asiago 48-inch reflector between October 22nd and November 20th. On the first date, the star's photographic magnitude was 19.5; maximum light, 15.0, occurred on November 14th; and six nights later the nova had faded to 16.3.

According to Dr. Rosino, the absolute magnitude at maximum was −9.2, considerably more luminous than typical Milky Way novae. Its brightness changes are, however, unusually slow for a nova of extreme luminosity.

Dr. Rosino reports his observations in *Circular* 1747 of the International Astronomical Union, where he gives the location of the new star as 12′.4 north and 52″ east of the nucleus of M31.

NEW COMET 1960n

An 8th-magnitude comet in Cepheus was discovered on December 26th by M. P. Candy, of the Royal Observatory in England. Subsequently astronomers at Sonneberg Observatory, East Germany, found images of Comet Candy on patrol plates taken on December 17th and 24th.

The new comet traveled rapidly southward, changing little in brightness. Perihelion passage will be on February 8th, according to Mr. Candy. He gives the following predictions of 1950 right ascensions and declinations: February 5, 23^h $30^m.8$, $+12° 52'$; 10, 23^h $33^m.8$, $+10° 19'$; 15, 23^h $36^m.4$, $+8° 07'$. The comet will be a 9th-magnitude object in the morning sky, passing from southern Pegasus into western Pisces.


At Fargo, North Dakota, on a calm night in late December, with the temperature slightly below zero, Dewey Bergquist recorded these rays in the sky caused by ground lights reflected from ice crystals floating in the air. Similar light pillars were seen by Terry Yorks in Syracuse, New York, on the same evening, December 27th.

LETTERS

Sir:

On the cover of the April, 1960, issue of SKY AND TELESCOPE, there was a picture of an "unusual aurora." The letters in the May issue, page 391, seemed to agree that this phenomenon was caused by ice crystals in the atmosphere.

During the evening of December 27th, I noticed pillars of light that looked exactly like the ones in the April photograph. But the night was overcast, and the "aurora" seemed to be on the wrong side of the clouds!

This was on my way to a theater located in a shopping center, where I saw that the columns in the sky were caused by the lights there. The temperature was about 10° Fahrenheit, and the air was full of snow flurries.

TERRY YORKS
104 Ormsby Dr.
Syracuse 4, N. Y.

Sir:

At 8 p.m. December 27, 1960, when the temperature was −4° F. and rising, I noticed towering frost-crystal spikes caused by lights in the center of town about a mile to the north of me. The effect was then noted in all parts of the sky, wherever there was a bright light source on the ground, and lasted about 90 minutes.

Automobiles on the main highway produced a solemn procession of rays that looked like an aurora; to the south a single spike moved above a car on a distant road. The cold, damp outside air caused my Rodenstock camera's lens to fog slightly. With Tri-X film at f/2.8, I exposed these pictures for 10 seconds.

DEWEY BERGQUIST
Station WDAY-TV
Fargo, N. D.

Sir:

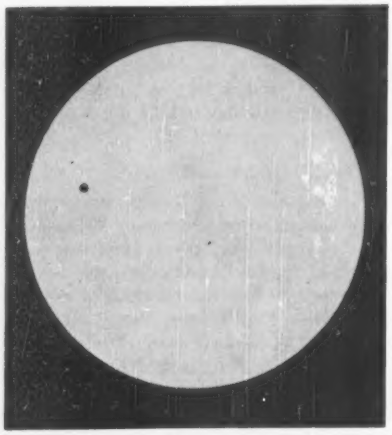
With the wide interest in the recent transit of Mercury, some readers might like to see the accompanying photograph of the last transit of Venus. It was taken on December 6, 1882, at Vassar College Observatory, where Maria Mitchell made visual observations of the contacts and directed the taking of photographs, assisted by Mary Whitney and several students.

I have been unable to find an exact description of the instrument used, except for this account in a local newspaper:

"The apparatus looks exactly like a section of stovepipe, about twenty-five feet long, supported in a horizontal position, with a glass at one end to reflect the image of the sun into the pipe, and a slide at the other to receive the sensitive plate. Two ladies were adjusting it, and a moment later one of them went into the observatory to get the plate. When she returned a slight delay took place but after a minute the plate was put into position, a lady took her stand at a chronometer, which stood on a chair close by, to note the time, the one in charge said 'Now!' and the next instant the plate was carried away to be developed."

Three of the original photographs are still in existence. They contain some flaws, and although there were sunspots visible that day, I cannot detect them on the original negatives.

HENRY ALBERS
Vassar College Observatory
Poughkeepsie, N. Y.



At 1:18 p.m., December 6, 1882, students at Vassar College took this picture of Venus (black disk) in transit across the sun. Small specks on the sun's face are photographic flaws, not sunspots. South is toward the top. Photograph from the archives of Vassar College Observatory.

ORDERS FOR BACK ISSUES

The stock of back numbers of this magazine for the first 16 volumes (November, 1941, to October, 1957) has been transferred to Johnson Reprint Corp., 111 Fifth Ave., New York 3, N. Y., from whom issues still in print may be ordered. That company is at present reprinting the first four volumes in photo-offset form, to be available later this year. Eventually, as demand warrants, other out-of-print numbers will be reissued.

Recent back numbers, Vols. XVII to the present (beginning November, 1957), should be ordered from the circulation office of SKY AND TELESCOPE, 49 Bay State Rd., Cambridge 38, Mass. All issues except April and November, 1958, and September, 1959, are in good supply. The price is 75 cents per copy, including mailing, $6.00 for 12 issues ordered at one time.

VIRGO A

Otto Struve

*National Radio Astronomy Observatory**

In 1948, John G. Bolton† announced the discovery of a new discrete source of cosmic radio emission in the constellation Coma Berenices. It was, therefore, originally named Coma Berenices A. However, position measurements of radio sources were still crude 13 years ago, and Bolton's original determination was off by about 30 minutes in right ascension and eight degrees in declination.

A year later, Bolton, G. J. Stanley, and O. B. Slee obtained a more accurate position with the help of sea interferometers. Such an instrument has one antenna, and measures the interference of the directly received beam and the beam that reaches the antenna after being reflected from the ocean's surface. Their improved position, $12^h\ 28^m$, $+12°\ 41'$, placed the radio source in Virgo, and enabled the Australian team to identify it with an elliptical galaxy, Messier 87 (NGC 4486), which is a member of the well-known cluster of galaxies in Virgo.

According to F. Zwicky, this large, nearby group of galaxies extends from 12^h to 13^h in right ascension, and from 0° to +20° in declination. It contains 16 objects listed by Messier, and has about 150 members in the Shapley-Ames catalogue.

†A staff member of the Commonwealth Scientific and Industrial Research Organization, Sydney, Australia, recently at California Institute of Technology.

Part of the extensive Virgo cluster of galaxies, from a photograph taken with Harvard's 24-inch Schmidt telescope. North is toward the upper right. The bright globular galaxy Messier 87 is left of center, and Messier 84 is nearest the lower right corner. Both are cosmic radio sources described in this article. See page 148 of the February, 1955, issue for a key chart identifying other galaxies in this picture. Harvard Observatory photograph.

The total number of galaxies in the Virgo cluster may be 2,500. About 12 degrees in diameter, according to C. W. Allen, the system is 13 million light-years distant, and its apparent velocity of recession is 1,200 kilometers per second. The brightest members, all galaxies of the elliptical type, are of apparent photographic magnitude 10.

Virgo A, as Bolton's discovery was renamed, is the fifth brightest discrete radio source in the sky (other than the sun) that we observe at a frequency of 100 megacycles per second. Like Cassiopeia A, described on page 190 of Sky and Telescope for October, 1960, the radio intensity of M87 at different frequencies shows that most of the emission is of the nonthermal or synchrotron type.

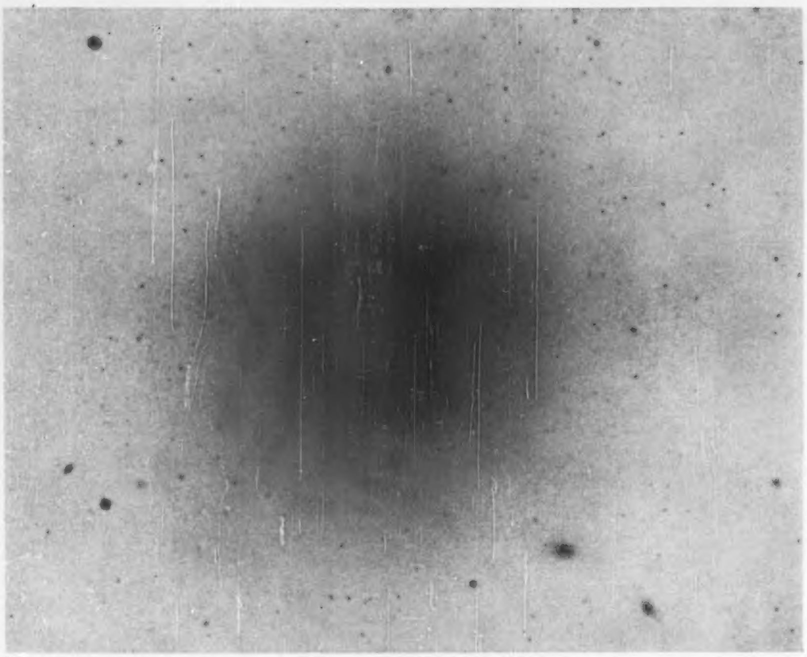
The luminous jet of M87 is shown divided into segments in this picture taken by the late Walter Baade with the 200-inch Hale reflector. North is at the top. Mount Wilson and Palomar Observatories photograph, reproduced from the "Astrophysical Journal."

M87 and its neighbor M84 are both globular in form, differing only slightly in optical brightness. But M87 has a very remarkable feature, shown on short-exposure photographs with large reflectors. This is a brilliant jet, extending out from the nucleus toward position angle 290 degrees. Longer exposures, such as the picture on page 88 made with the 200-inch Palomar telescope, reveal a rich envelope of globular clusters surrounding this galaxy.

The jet is about 20 seconds of arc long, and averages two seconds in width. This feature is much bluer than M87 itself, and according to M. Humason its optical spectrum is continuous, without absorption or emission lines.

In 1956, W. Baade took direct photographs through a polaroid filter, to dis-

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.



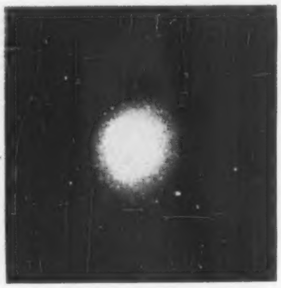
Scores of globular clusters appear as hazy specks surrounding the galaxy M87, in this negative print of a long-exposure picture taken with the 200-inch Hale reflector. Mount Wilson and Palomar Observatories photograph.

cover that light from the condensations in the jet is strongly polarized (see November issue, page 261). The inner and outer knots are brightest with the filter in one position, but the middle condensation appears brighter when the polaroid is turned through a right angle. Baade's findings were confirmed and extended in 1959 by W. A. Hiltner at McDonald Observatory. Armin J. Deutsch finds the jet exceedingly brilliant when observed visually with the 200-inch telescope. Apparently its optical radiation is of the synchrotron type, resembling the diffuse light of the Crab nebula, which is the supernova remnant in the constellation Taurus.

Baade and R. Minkowski have found M87 to have a normal G-type spectrum, but superimposed on its nuclear region is a strong forbidden emission line of ionized oxygen. With reference to the overall spectrum, this line is displaced toward the violet by an amount corresponding to a 300-kilometer-per-second velocity of approach. The two Palomar astronomers suggested that the jet was formed by ejection from the nucleus, and that the oxygen emission line comes from jet material that is still very close to the nucleus, if not inside it.

Radio astronomers have devoted much effort to correlating the radio-brightness distribution with optical features of M87. In 1953, B. Y. Mills in Australia found that the radio emission comes from an elliptical area, whose major axis is approximately at right angles to the jet. Last year Bolton announced that Virgo A has a double brightness distribution. There is an extended source roughly 10 minutes of arc in size, and a source smaller than one minute of arc, presumably associated with the jet.

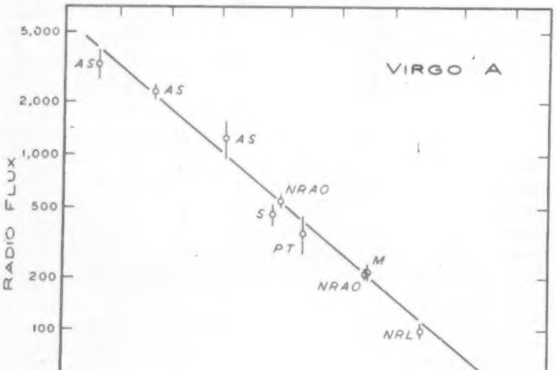
Another Caltech radio astronomer, Alan T. Moffet, discussed the radio spectrum of Virgo A at the December, 1960, meeting of the American Astronomical Society. His chart shows how the flux from the entire source increases markedly with decreasing frequency. However, the relative contributions from the small source (core) and the large one (halo) change along the spectrum. Recent French work from Meudon Observatory shows that at 1420 megacycles the core provides 60 per cent of the total flux. Moffet's own measurements at 958 megacycles indicate the core contributes half. At the still lower frequency of 101 megacycles, Mills attributes not more than one-fourth of the total energy to the small component. The diameters of core and halo are 0.6 and 6.5 minutes of arc, respectively, according to Moffet's observations.



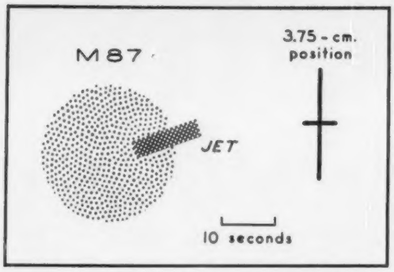
A comparison of M87 as it would look to eyes that could see radio waves (right) and as it appears in photographs (left). North is upward, and the radio ellipse is roughly at right angles to the jet. After B. Y. Mills, from "Australian Journal of Physics."

All these results seem to indicate differing radio spectrum energy distributions for the core and halo, the former dominating at higher frequencies. The flux from the large source changes directly with the wave length, while the core varies as the 0.35 power of the wave length. But at 8000 megacycles, observations at the National Radio Astronomy Observatory give an unexpected steepening to the core's spectral curve. Nevertheless, the dual nature of Virgo A is consistent with Moffet's preliminary survey of brightness distributions in 130 radio sources. He finds some sources contain a core and a halo, while others have a double-peaked structure resembling Cygnus A.

At Green Bank recently, Frank D. Drake measured very accurately the po-



Radio flux measurements of Virgo A at different frequencies are compared with a straight-line trend in A. T. Moffet's diagram. Symbols AS indicate data by Adgie and Smith (Cambridge, England); S, Seeger and others (Leiden, Netherlands); PT, Piddington and Trent (Sydney, Australia); M, Metzer (Bonn, Germany). Also, NRAO is the National Radio Astronomy Observatory, NRL the Naval Research Laboratory, both in the United States.

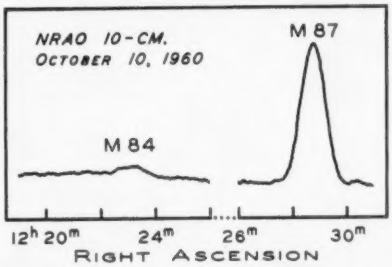


F. D. Drake measured the position of 3.75-cm. Virgo A radiation as at the center of the cross; lengths of its arms indicate uncertainty range. All charts on this page are courtesy of the National Radio Astronomy Observatory, Green Bank, West Virginia.

sition of the center of Virgo A's radio emission. His observations with the 85-foot Tatel telescope were made at a wave length of 3.75 centimeters, and place the radio center about 30 seconds of arc northwest of the optical center of M87. As the chart shows, the jet extends approximately in this direction.

In 1958, at the Paris symposium on radio astronomy, C. A. Shain reported that Mills had observed a faint extension of radio emission, reaching out a degree or more from M87, approximately in the direction of the jet. This finding gained new significance from Campbell M. Wade's discovery at NRAO this past fall of a new radio source in the Virgo cluster which he identifies with M84 (NGC 4374). The new source, about 1/30 the strength of Virgo A, is located along the line of the jet, and it may account for the faint extension found by Mills.

On ordinary photographs M84 does not look unusual; it seems a globular galaxy about as bright as M87. But A. Sandage has found a series of short-exposure plates of M84, taken by the late Edwin P. Hubble with the 100-inch telescope at Mount Wilson Observatory. Several of these pictures, especially one exposed for 15 seconds, show a central band of absorbing material, possibly similar to the conspicuous dark lane crossing NGC 5128, the intense radio source Centaurus A, which is pictured on page 260 of last November's issue.



These 10-cm. radio scans of M84 and M87 were made in direct succession by Dr. Wade on October 23, 1960. The broken line indicates resetting the telescope from a declination of +13° 07′ for M84 to +12° 37′ for M87. The peak deflection on M87 corresponds to an antenna temperature of 10° Kelvin, that on M84 to 0.6°. The half-power beam-width was 16 minutes of arc.

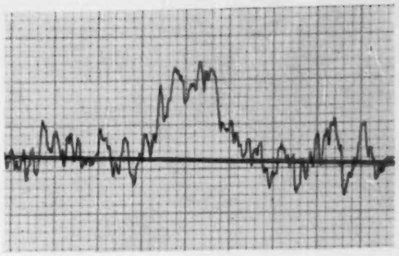
The physical nature of M87's bright jet remains unexplained. I. S. Shklovsky has suggested that it shines by synchrotron radiation emitted by fast-moving electrons in a magnetic field (see page 192 of the October, 1960, issue). He points out that the jet's surface brightness is 100 times greater than that of the diffuse light of the Crab nebula. The jet condensations have linear dimensions of about 300 light-years, while the Crab is only three light-years in diameter. Hence, the emission per unit volume is roughly the same in both objects.

If the magnetic field in each case is about 10^{-4} gauss, the production of the jet's optical synchrotron light would require electrons with energies of about 5×10^{11} electron volts. About one of these high-energy electrons per 10^{8} cubic centimeters would be needed in the jet.

Undoubtedly, such fast electrons would diffuse gradually from the jet throughout the rest of the M87 galaxy, in the course of several million years. They could account for the larger radio source discovered by Bolton. The radio emission from both the large source and jet could be produced by slower electrons, with energies of about 10^{8} electron volts, there being about three such electrons per 10^{8} cubic centimeters.

Shklovsky makes the following surmise regarding the origin of the jet:

"It would be natural to think of some explosion of grandiose proportions, exceeding by far even such exceptional phenomena as supernova outbursts, perhaps with 10^{7} times as much energy. The mass equivalent of the energy released would be about 100 suns."



As the galaxy M84 drifted through the beam of the 85-foot Green Bank dish, Campbell Wade obtained this high-sensitivity record of its 10-cm. radiation. The integrating time here was only five seconds, compared to 20 seconds for the tracings of M84 and M87 at the bottom of this page.

No galaxy save this giant elliptical system M87 definitely has a jet; it may well be that these gigantic explosions occur only in ellipticals. Since the remnants — the jets — presumably persist for millions of years, they may be quite rare, or we should see more of them, as there are many elliptical galaxies.

Yet there are other giant ellipticals, such as Centaurus A and M84, that do not now possess optical jets though they are strong sources of radio emission. The synchrotron radio emission perhaps lasts very much longer than its optical counterpart. The Crab nebula source is 900 years old and emits both, whereas the great Cygnus loop, perhaps 50,000 years of age, emits radio synchrotron radiation but not optical. Could it be that the equatorial bands of absorbing material in NGC 5128, for example, represent the aftermath of a jet explosion?

QUESTIONS... FROM THE S+T MAILBAG

Q. Why are three observed positions of a new asteroid needed for calculating its orbit?

A. Each observation gives three items of information: a right ascension, declination, and time. To compute the orbit, eight unknowns must be evaluated: two elements to define size and shape of the orbit, three elements to specify the orientation of the orbit, and a sixth giving time of perihelion; in addition, two distances to the asteroid must be found. Hence a minimum of three observations, providing nine items of information, are required.

Q. What periodic comets are expected to return in 1961?

A. According to the *Handbook* of the British Astronomical Association, Comets Encke, Comas Sola, Forbes, and Schwassmann-Wachmann 2 are successively due to pass perihelion in 1961. In addition, Comets Grigg-Skellerup, Perrine-Mrkos, Harrington-Abell, Tempel 2, and Faye, all of which come to 1962 perihelia, may be recovered in 1961.

Q. What are the distinctive properties of *S*-type stars?

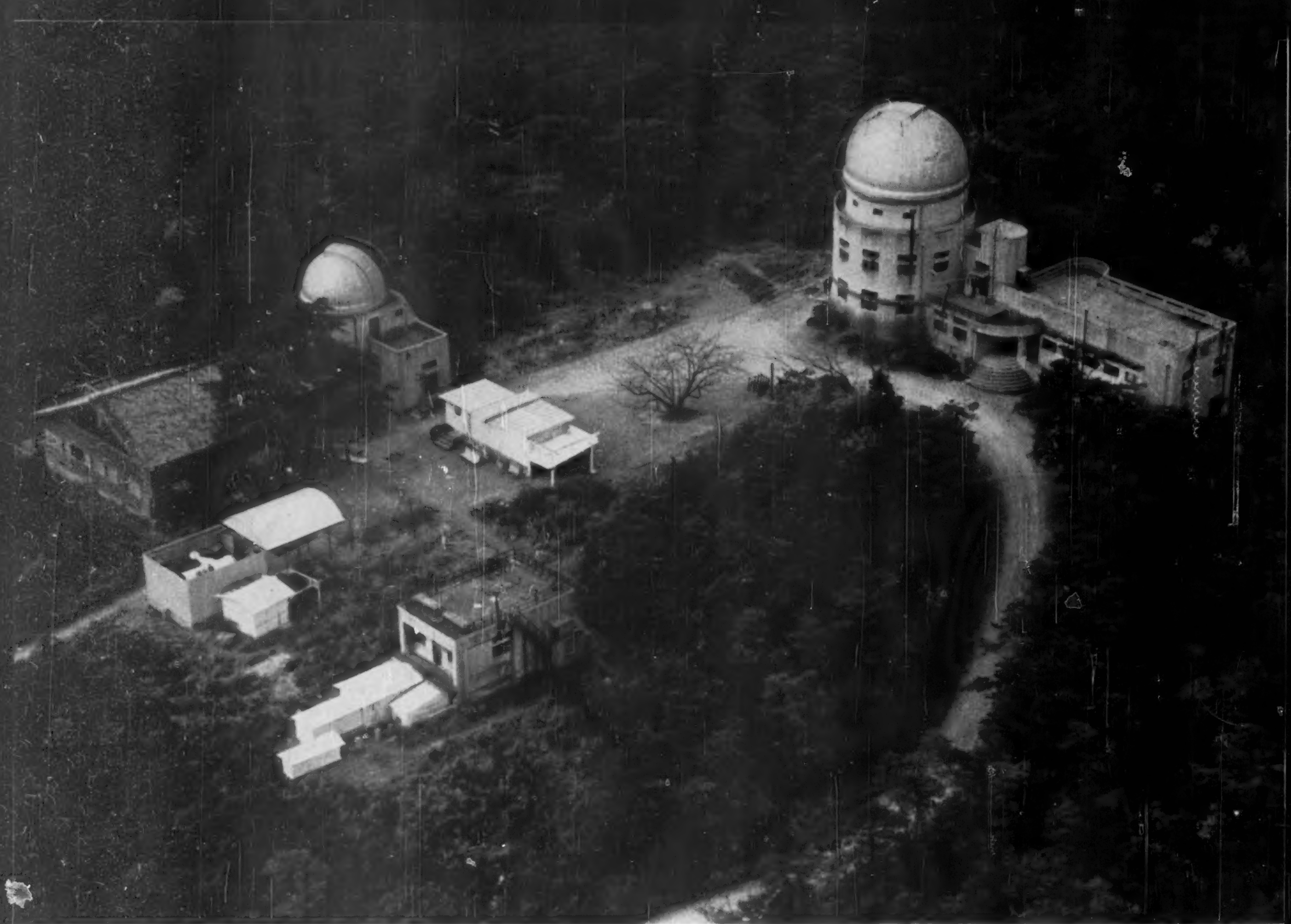
A. This rare class consists of cool, red stars, much like those of class *M*, except that their spectra show dark bands of zirconium oxide. Most *S* stars vary in brightness.

Q. What is the extent of the United States in longitude?

A. The easternmost point in Maine is at longitude 67° west, the westernmost part of the Aleutian Islands at 174° east. From 67° west to 180° is 113°, and from 180° to 174° east is 6°, giving a total of 119° — almost a third of the angular distance around the globe.

Q. Is a solar-rate clock drive suitable for star and planet observations?

A. Yes. The slight error of the difference between solar and sidereal driving rates is negligible for general observing and short-exposure photography; it is easily corrected with the telescope's slow-motion controls. W. E. S.



At about 136° east longitude and 35° north latitude, 240 miles west of Tokyo, the Kwasan Observatory stands on a hilltop. It is staffed by five astronomers. At the left in this picture is seen the opened roof of the temporary housing for the new 23½-inch Cassegrainian reflector, while at upper right is the dome for the 12-inch refractor. All photographs with this article were supplied by the author.

Kwasan Observatory in Japan

SHOTARO MIYAMOTO, *University of Kyoto*

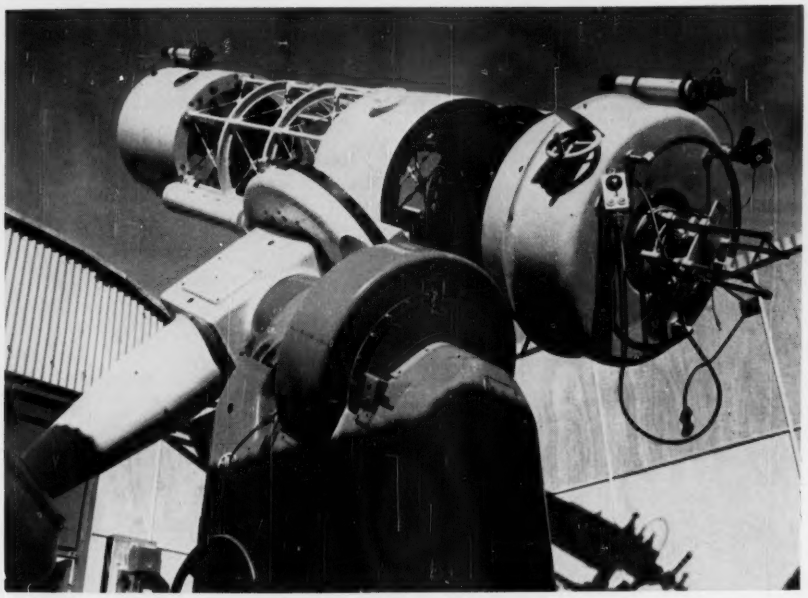
EAST of the city of Kyoto, on the mountain backbone of Japan's largest island, Honshu, stands Kwasan Observatory. It is named for the round, flat-topped hill on which it is situated, about 720 feet above sea level. Its telescopes are shielded from the lights and smoke of Kyoto by several other hills, and in nearly every direction there is a vista of the mountains of central Japan. The observatory, established in 1929, belongs to the science faculty of the University of Kyoto.

The picture on this page is an enlarged aerial photograph showing six of our buildings. The camera faced approximately toward the northwest; a more exact orientation is provided by the north-south slit of the meridian house, in the center of the picture, for the 3½-inch Askania transit instrument. On top of the five-story main building is a 30-foot dome that shelters our 12-inch f/15 Cooke refractor. The smaller dome contains a 7-inch Zeiss-Sartorius telescope.

Observations of the sun are an important part of our work. In the foreground of the picture above is the solar laboratory, containing a 12-inch coelostat and a darkroom. A new building for solar spectroscopy is now under construction, and should be completed in April this year. Its 27½-inch coelostat and spectroheliograph will greatly facilitate our solar program.

Between the solar laboratory and the astronomers' dormitory stands the sliding-roof temporary housing of our new Cassegrainian reflector, designed especially for lunar and planetary photography. Its f/5.5 primary mirror has an aperture of 23½ inches. The instrument is equipped with automatic moon and planet cameras, and its driving worm was precisely lapped to avoid any irregularity in the motion of the telescope. This reflector was constructed by the Tsugami firm of Tokyo, Japan.

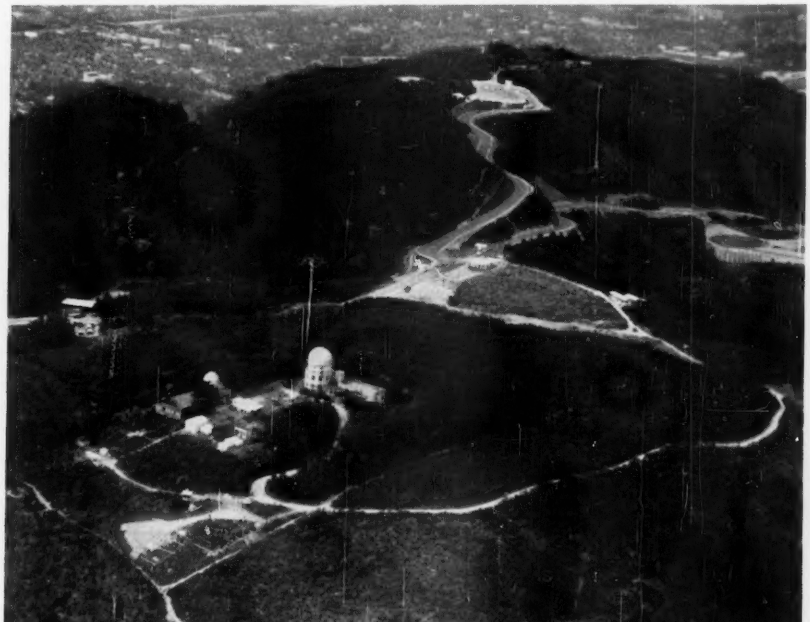
As the description of our equipment indicates, most of the work at Kwasan Observatory concerns objects in the solar system. Investigations of the sun's spectrum, the meteorology of Venus and Mars, the moon's surface, and the earth's upper atmosphere are now in progress. We are participating in the international campaign for co-operative observations of Mars, under the direction of A. G. Wilson at the Rand Corporation in Santa Monica, California. Our activities are closely re-



Kwasan Observatory's newest large instrument is this 23½-inch reflector designed especially for lunar and planetary observing. At the Cassegrainian focus, note the brackets attached to carry automatic cameras. Curved hand rails on the mirror cell provide for manual slewing of the instrument. The guide telescope is revealed by part of its shadow (lower right).

lated to the theoretical work at Kyoto University's Institute of Astrophysics, treating the atmospheres of the sun and stars, Fraunhofer lines, radiative transfer, and planetary nebulae.

During the years 1958 to 1960, the 12-inch refractor was employed in taking photographs of the moon under many different illuminations. To obtain the best definition, the pictures were made in orange light with the aperture reduced to nine inches. A lunar atlas consisting of 85 of these pictures has recently been published as *Contribution* No. 95 of the Institute of Astrophysics and Kwasan Observatory, Kyoto University. Intended to aid interpretation of the moon's surface features, these photographs will be supplemented by larger-scale ones taken with the 23½-inch reflector.



Beyond Kiyomizu and Shoogun-duka hills lies Kyoto, the third largest city in Japan and the national capital from 794 until 1868. Though it is relatively near the city, the observatory is well shielded by the hills.

OBSERVING THE SATELLITES

(Continued from page 83)

land; NBA in the Canal Zone; WWV at Beltsville, Maryland; and WWVH in Hawaii. As a result, the time signals from the two last stations, operated by the National Bureau of Standards, have been retarded by 0.005 second, beginning with January 1, 1961, to bring them into closer agreement with the other three.

This change will not require any alteration in procedure by those who have been using the corrections to WWV signals published at intervals by the U. S. Naval Observatory. At Washington, the observatory compares WWV time signals with those from many other stations, with its own cesium-beam atomic clock, and with astronomical observations of stars.

Variations in the propagation path length limit the accuracy to which a satellite-tracking station can compare its own clock with WWV. In some parts of the world, there is the further difficulty that other transmitters are simultaneously broadcasting their time impulses on the same standard frequencies. At the Smithsonian Astrophysical Observatory's satellite-camera sites, this problem is usually solved by orienting the antenna specifically for WWV, and by choosing a time of day when WWV's signal is strongest relative to the others.

A second, more conspicuous change in WWV's practice, introduced on the same date, may be noticed by anyone who tunes in on one of its frequencies — 2.5, 5, 10, 15, 20, or 25 megacycles. The station now broadcasts 10 times per hour a special high-speed timing code. It comes at the seventh minute after the start of each hour, and every fifth minute thereafter, except on the 47th, during WWV's silent period.

Too fast to interpret by ear, this code can be read by appropriate recording devices. It tells the day of the year, hour, minute, and second, and also provides 0.01- and 0.1-second markers. The numbers are coded in a binary system, utilizing one-kilocycle tones of two different durations. A one-second rhythm can be heard, as before.

A circular containing information for users of WWV and WWVH time signals can be obtained by writing the National Bureau of Standards, Boulder Laboratories, Boulder, Colo.

Satellite trackers as well as astronomers throughout North America make wide use of the signals originating from the Dominion Observatory, Ottawa, Canada. These are broadcast on frequencies of 3.33, 7.335, and 14.67 megacycles. A particularly convenient feature for the amateur is the voice announcement identifying each minute. The Dominion Observatory distributes a descriptive leaflet.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.

ASTRONOMICAL SCRAPBOOK

J. N. Krieger: The Moon Half-Won

THERE is an often quoted complaint of W. H. Pickering about lunar terminology: As a general rule, the larger a crater, the smaller the contribution to selenography by the man after whom it was named. Great observers like Mädler and Schmidt have been honored with minor formations, while the huge ring plain Plato is called after a philosopher whose addition to our knowledge of the moon's surface was probably nil.

The earthly fame or obscurity of a selenographer also is sometimes an untrustworthy measure of his merits. For example, there are major figures from central and eastern Europe whose work is almost unknown by English-speaking amateurs, mainly because their writings are hard to find or use inconvenient languages.

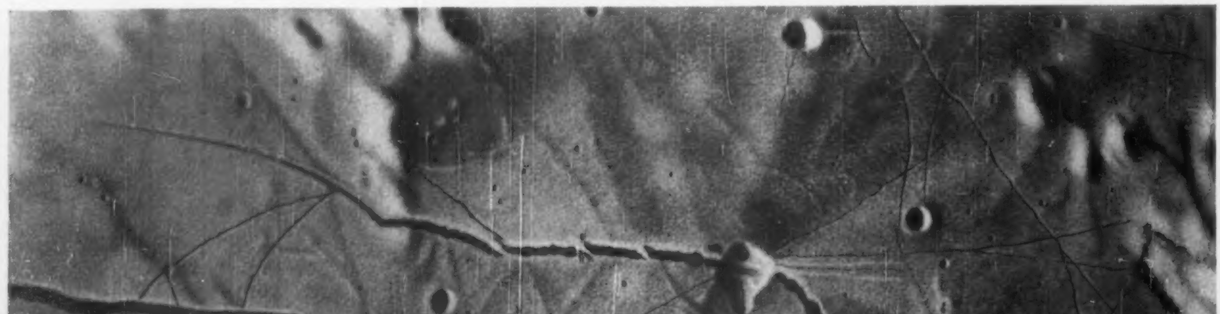
A case in point is the German observer, Johann Nepomuk Krieger (1865-1902), whose beautiful lunar drawings were of an excellence that remains perhaps unmatched to this day. The brief allusions to Krieger in some recent books fail to convey the importance of his moon atlas. The portion of it he managed to complete before his early death is still a storehouse of information.

Krieger's career was like that of many other amateurs, but with greatly enhanced lights and shadows. His intense urge to become an astronomer originated from a desire to escape the limited daily life of the mountain hamlet of Unterwiesenbach in Bavaria, where he was born on February 4, 1865. There his father ran a small brewery and an inn, in which the boy started work at the age of 15, after a year in agricultural school.

It is not quite certain how his attention first turned to astronomy, whether from books or through a fellow townsman nicknamed "the stargazer." But he early obtained a small telescope and began active observing, especially of the moon. In 1886, Krieger visited Hermann Klein in Cologne, for advice on his future. Klein was Germany's outstanding popularizer of astronomy at that time, the author of several good books for amateurs and the editor of the journals *Copernicus* and *Gaea*. A skillful lunar observer himself, Klein had translated E. Neison's famous monograph, *The Moon*, from English into German.

The Cologne professor warmly encouraged Krieger to go on with a career in selenography, and urged him to study the mathematics that had been omitted in a spotty education. Klein also advised mastering the graphic arts and photography. Furthermore, he gave Krieger an introduction to Hugo Seeliger, the director of Munich Observatory, who became a lifelong friend.

By selling the brewery after his father's death, Krieger obtained the money to move to Munich, where he attended university classes in mathematics, physics, and astronomy. But it was not long before he knew that he had neither the background nor the taste for mathematics, and that his future in astronomy must be as an amateur.



J. N. Krieger's chart of the Hyginus rille and its surroundings was based on 34 nights' work with a 10½-inch refractor. It is reproduced on slightly reduced scale from his 1912 atlas. The 59 rilles in the picture have a combined length of two-thirds the moon's diameter. Compare with Gilbert Fielder's drawing in the April, 1960, issue (page 337).

The Bavarian amateur J. N. Krieger (1865-1902) was one of the finest lunar observers of all time. This portrait is reproduced from the frontispiece of his 1912 "Mond-Atlas."

Krieger thereupon built an observatory in the Munich suburb of Gern-Nymphenburg, equipped with a good 10½-inch refractor. Here he began his life's work, the task of accurately charting the moon's surface in a systematic manner.

This has been the ambition of many amateurs, but Krieger's long and careful preparations put him in a class by himself. Although the keen-eyed German showed much skill in drawing, this was not inborn, but developed through persistent effort. From the start, he realized the value of charts that everywhere reach the same level of detailedness: "The selenologist who finds that some small area, randomly chosen, has been delineated with utmost minuteness will easily attach undue importance to it, perhaps basing an evolutionary theory on what was really faulty planning by the observer."

To get this uniformity, Krieger habitually worked with a power of 260, also reducing his 10½-inch aperture to 6½ inches. On first looking into the eyepiece with full aperture at this magnification, he could see fine details that became quite invisible a few minutes later, owing to glare. In the best seeing, when the full objective was usable with very high powers, there was more fine structure than could be sketched.

Krieger's most important innovation was to use low-contrast prints of large-scale moon photographs as the base for his drawings, thereby insuring accuracy in the placement and sizes of lunar features. This valuable technique has been surprisingly little used by other workers until fairly recently. At first, Krieger was provided by Klein with photographs taken with the Lick 36-inch refractor; later, he used mainly Paris pictures sent him by M. Loewy and P. Puiseux.

The years 1890 to 1894 were spent in developing skills and techniques, and Krieger regarded them as a practice period, preliminary to his main effort. The 28 best of the 125 drawings from that time were published in 1898 at Trieste as the first volume of Krieger's atlas.

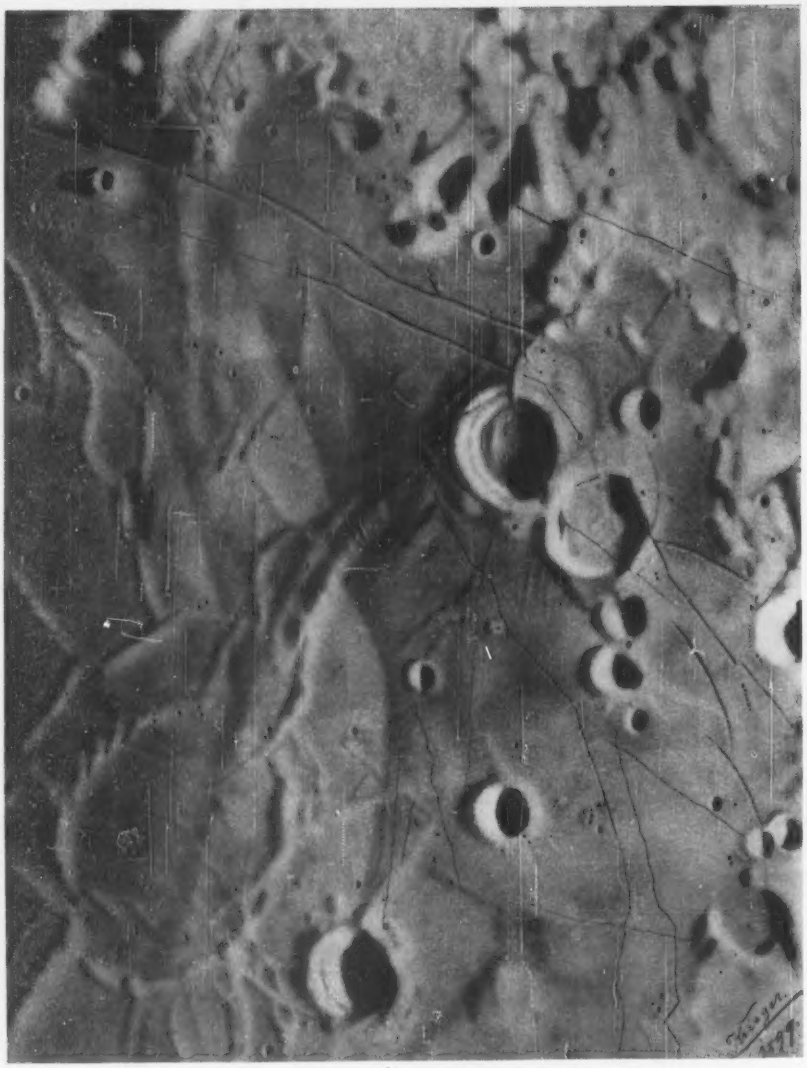
In 1895 he transferred the observatory from the northern side of the Alps to the southern, where he hoped to find clearer skies and steadier seeing at Trieste, near the head of the Adriatic Sea. The year 1896 was spent in readying the new Pia Observatory, which Krieger named after his wife. Finally, in 1897 he resumed his labor with great energy, securing 103 drawings in the first half year.

Krieger had now refined his method to assure utmost reliability. For each lunar area to be charted, a photographic print was chosen with a scale of about 12 feet to the moon's diameter. At the telescope, additional features were entered on the same print during 10, 20, or more nights, with a different colored pencil each night, so that the color was a key to the date when a particular feature was noted.

Next, all these markings were neatly transferred to a second print. On a night of good seeing, when the throw of shadow on the moon matched that when the photograph had been taken, this print was compared with the moon and corrected. Finally, a finished copy would be made on a third print using lead pencil and charcoal, to serve for reproduction in the new atlas.

In this laborious way, Krieger produced depictions of the moon's surface that are startlingly superior to almost all other

The lunar crater Gassendi, 69 miles in diameter, has fascinated generation after generation of amateur observers, because of the delicate maze of hills, ridges, rilles, and pits on its broad floor. Krieger spent parts of 15 nights making this faithful depiction, here reproduced from Plate 46 of his 1912 atlas. South is above, west to the left.



The eastern part of Mare Tranquillitatis, from Plate 30 of Krieger's atlas, is remarkable for the complex pattern of ridges and rilles, 39 of the latter being charted here. The crater at the bottom is Arago, with a large low dome to its right. In the upper left, the small crater Moltke casts a long shadow. This is the same area described by Brian Warner on page 286 of the November, 1960, issue.

amateur efforts, in meticulous accuracy, aesthetic appeal, and legibility. They give an uncomfortable feeling that most later visual work falls short of his standards.

Krieger's hope to cover the entire visible face of the moon in this fashion was never fulfilled, despite his single-minded energy. The year 1898 was one of ceaseless activity, yielding 458 observations on 92 nights. His days were spent preparing photographic bases, collating and finishing drawings, and doing the many chores of an active one-man observatory. This, too, was when he published the first installment of his atlas, and when he was involved in an acrimonious controversy forced upon him by Philipp Fauth. The same pace continued through 1899.

But this incessant toil, all-night vigils followed by full days in his office, finally broke down Krieger's health. The collapse came in 1900. His doctors told him to stop observing and to move to a gentler climate. He dismantled his observatory in January, 1901, giving the 10½-inch telescope to the Austrian naval observatory at Trieste.

The next months were spent at sanatoria in Italy, as the desperately ill man sought to finish the text for the second part of his atlas. From his sickbed he continued to dictate to a friend until the power of speech was lost. The end came at San Remo, in the Italian Riviera, on February 10, 1902, just after his 37th birthday.

The incomplete manuscript, together with hundreds of drawings ranging from finished products to rough sketches, eventually came into the hands of Krieger's old friend, Professor Seeliger. The latter wisely chose the very able Austrian selenographer Rudolf König to edit and reconstruct the atlas. The work appeared in 1912 as two magnificent volumes, published by the Vienna Academy of Sciences under the title *Joh. Nep. Kriegers Mond-Atlas – Neue Folge.*

One volume is an album of 58 large pictures of lunar regions, some never completed. Each plate has a transparent overlay, bearing key numbers and letters for scores of formations of interest. The other volume is text, containing long and detailed descriptions of each region. Some of these were written by Krieger, but most of them by König with the aid of the original observing books and papers. The amount of detailed information, historical and new, is remarkable, and testifies eloquently to König's familiarity with both lunar literature and lunar topography.

JOSEPH ASHBROOK

VARIABLE STAR BIBLIOGRAPHY

The flood of new technical literature in astronomy is so enormous that it is difficult for an astronomer to stay informed on research in his particular field of interest. This situation is especially formidable for the variable star worker who wishes to collect all available information about some one of the more than 15,000 known variables. The data needed are scattered among many hundreds of journals and observatory publications from all parts of the world.

At Potsdam Observatory in East Germany, H. Schneller is preparing a complete bibliography of all stars officially recognized as variable between 1938 and 1958. The first of three large volumes has been published, with the histories, descriptions, and full references for 2,190 stars in the constellations extending alphabetically from Andromeda to Cygnus. The publications cited are from 30 countries.

This is a continuation of the monumental *History and Literature of the Variable Stars*, begun before World War I by G. Müller and E. Hartwig, and extended by R. Prager, P. Guthnick, and Dr. Schneller. The eight previous volumes covered all variable star literature up to 1938.

CHARLOTTE MOORE SITTERLY HONORED

A leading American astronomer and physicist, Mrs. Charlotte Moore Sitterly of the National Bureau of Standards, has been awarded the U. S. Department of Commerce's gold medal for exceptional service. Her many contributions to spectroscopy include tables of basic atomic data, in constant use by every astronomer who works with stellar spectra. Mrs. Sitterly is well known for her researches at Lick, Princeton, and Mount Wilson observatories on the chemical composition of the sun.

Amateur Astronomers

THIS MONTH'S PROGRAMS

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. February 1, Dr. Warren F. Goodell, Jr., Columbia University, "Cosmic Splinters."

New York, N. Y.: Junior Astronomy Club, 8 p.m., Waverly Building, New York University. February 17, Prof. Serge A. Korff, New York University, "Astrophysical Implications of Cosmic Rays."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. February 10, Dr. C. S. Draper, Massachusetts Institute of Technology, "Inertial Guidance System."

Plainfield, N. J.: Amateur Astronomers, Inc., of Union County, 8 p.m., Stillman School. February 17, symposium, "Recent Astronomical Developments."

San Francisco, Calif.: San Francisco Amateur Astronomers, 8 p.m., Randall Junior Museum. February 1, O. Richard Norton, Morrison Planetarium, "How To Guide Yourselves at Night by the Stars and Constellations."

TWO CLUBS IN INDUSTRY

Employees and their families at the Martin Co. in Denver, Colorado, and at Lockheed Aircraft Co. in Sunnyvale, California, have organized amateur astronomical societies at the respective plants.

The Martin-Denver Astronomy Club meets the third Friday of the month at Chamberlin Observatory, under the chairmanship of D. Hollinbeck, 2265 Burton Place, Littleton, Colo.

Thirty-four members comprise the Skyline Astronomical Society. The correspondent is E. J. Sanislo, Lockheed Employees Recreation Club, Dept. 83-32, P. O. Box 504, Sunnyvale, Calif.

TAPE RECORDING CLUB?

The use of tape recorders has fast become a hobby for many persons, and several clubs have been formed in which members exchange tapes telling of their special interests. Except for actual meetings, this is the best means of communication, much more stimulating than letter writing.

Perhaps a tape-exchange organization could be set up among amateur astronomers, either by individuals or societies. Useful information might be shared, and a firmer feeling of fellowship established.

Interested persons are invited to contact the undersigned, perhaps by tape, giving their ideas on developing such a program.

JARL V. PLOTTNER
1106 Field St. N. W.
Canton 9, Ohio

ED. NOTE: SKY AND TELESCOPE is ready to publish the tape topics and addresses of readers who have recordings to exchange.

+++ AMATEUR BRIEFS +++

Members of societies in the San Francisco, California, area are being offered a discount for admission to the Morrison Planetarium in Golden Gate Park. This courtesy is extended to those with membership cards or identifying letters from club officers.

Edward Guries, Jr., a student at Nichols College in Dudley, Massachusetts, is rebuilding his school's 8-inch reflector and putting its little-used observatory back into working order. He's also the youngest member of the Aldrich Astronomical Society in Worcester.

The December bulletin of the Hawaiian Astronomical Society chronicled the winter solstice and then added gleefully, "Unofficially, we hardly recognize such an event in Hawaii!" That's no comfort for us northerly observers these wintry nights!

To accommodate the many Spanish-speaking persons in New York City, the American Museum-Hayden Planetarium conducted special showings of its Christmas presentation in that language. A year-round schedule of Spanish-language shows is being considered.

Six members of the Ft. Wayne, Indiana, Astronomical Society have been kept busy giving astronomy lectures to civic, cultural, educational, and religious groups in the area. The club set up a speakers' bureau to accommodate the great demand.

The Yakima, Washington, Amateur Astronomers have confidence in their

A SLIDING - ROOF OBSERVATORY

MY PARTICIPATION in amateur astronomy was renewed about four years ago when I returned to California from the Midwest. I first built a portable 6-inch reflector and followed it with an f/12 8-inch. After using this equipment for two years, I decided to build an observatory to eliminate the nightly reassembling of the telescopes, which by day were stored in the garage.

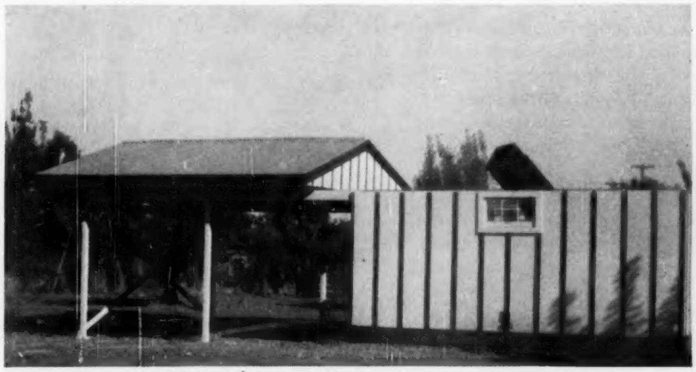
The building was constructed in about a month, during weekends and in my spare time. It is 16 feet square with a wall height of six feet nine inches. The interior headroom with the roof closed is nine inches greater, because the ceiling joists are set on top of the longitudinal girders that carry the roof weight.

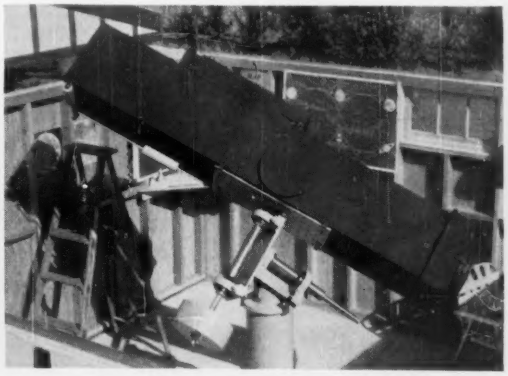
Angle iron, $1\frac{1}{2}$ by $1\frac{1}{2}$ by 3/16 inches, makes up the roof track. Alignment is not critical, since the four ball-bearing wheels are allowed to shift up to two inches along their axles. Binding between the wheels and track is thus eliminated.

The $\frac{1}{2}$-inch plywood walls are nailed firmly at each stud, to give the rigid structure needed in a building that is not tied together by a conventional roof. The sliding roof is $\frac{1}{4}$-inch exterior plywood covered with 5-V crimp aluminum, which helps lower the interior daytime temperature.

At present the observatory contains a $12\frac{1}{2}$-inch f/8 and a 6-inch f/5 reflector mounted together, both with excellent optics. A nine-point flotation system supports the $12\frac{1}{2}$-inch mirror. An electric drive is now under construction. I am a member of the Mt. Diablo Astronomical Society.

JAMES W. FORBES
157 LaSonoma Way
Alamo, Calif.





At the left is James W. Forbes' observatory in Alamo, California, with the roof pushed open for a viewing session. His $12\frac{1}{2}$-inch reflector is at the right, with a 6-inch telescope mounted on top of it. Maps and charts decorate the walls.

junior members. Three were elected to top offices: Randy Prokop, president; Tommy Lynch, vice-president; and Sandra Prokop, recording secretary.

G. M. Joseph, of Carlisle, Pennsylvania, has come up with a solution of how to carry his Japanese-size eyepieces in his pocket and still protect them from dust and accidents. They fit exactly in Kodak 35-mm. film cans. The remaining problem is to identify them in the dark.

A telescope making class will be conducted by the Indiana Astronomical Society this spring. Further information may be had from William Graney, Chemistry and Physics Dept., Technical High School, Indianapolis, Ind.

Potpourri! Among the many telescope makers at three separate courses being sponsored by the National Capital Astronomers of Washington, D. C., are Marine Corps colonels, World Bank officials, Congressional staff members, druggists, chemists, housewives, engineers, biologists, and members of foreign diplomatic staffs.

Florida vacationers are invited to visit the observatory of the Southern Cross Astronomical Society at the recently dedicated Miami Museum of Science and Natural History. A planetarium is also in operation.

Junior sections have been organized by the Sacramento Valley Astronomical Society in California and by the Grand Rapids, Michigan, Amateur Astronomical Association.

Thru-the-Eyepiece, though primarily the publication of the northeast and central Iowa divisions of the Great Plains Astronomical Society, also carries news from amateurs elsewhere in the state, as well as from Kansas and Nebraska. A year's subscription costs $1.00, and may be ordered from Bill Bailey, Box 447, Clarksville, Iowa.

Some diverse projects have been undertaken by Optical Division members of New York's Amateur Astronomers Association. Frank Manasek is assembling a 12½-inch f/9 Newtonian; its tube is of square lattice-work aluminum. Ralph Rosenburg is making an 8-inch reflector with a Swiss letterbox-type tube that will break into three sections for easy portability. Robert Fisher is building a 10-inch f/5 modified Cassegrainian and a spectroscope.

H. M. C.

CONTACTING NATIONAL ORGANIZATIONS

Many amateurs are interested in becoming connected with a national organization. Information may be obtained from the officers listed here.

American Association of Variable Star Observers. Mrs. Margaret W. Mayall, Director, AAVSO, 4 Brattle St., Cambridge 38, Mass.

American Meteor Society. Dr. Charles P. Olivier, President, AMS, 521 N. Wynnewood Ave., Narberth, Pa.

Association of Lunar and Planetary Observers. Walter H. Haas, Director, ALPO, Pan American College Observatory, Edinburg, Tex.

Astronomical League. Mrs. Wilma A. Cherup, Executive Secretary, AL, 4 Klopfer St., Pittsburgh 9, Pa.

IGY Auroral Data Center. Dr. Carl W. Gartlein, Cornell University, 420 Hollister Hall, Ithaca, N. Y.

Western Amateur Astronomers. Mrs. Ruby Perkins, Secretary, WAA, 4636 Vineta Ave., La Canada, Calif.

VAN NUYS, CALIFORNIA

During the September lunar eclipse, the 13-member Van Nuys Astronomical Society timed passage of the umbra over various craters, searched for circumlunar satellites, and took color photographs of the event. A current project is determining photographically the heights and paths of meteors.

Under construction are telescopes ranging from a 4-inch reflector to a 12-inch off-axis instrument, as well as an astrograph and a spectrohelioscope. Further information is available from Ronald Chaldu, 14312 Cohasset St., Van Nuys, Calif.

TELESCOPE MAKING – SOME BRITISH VIEWS

A recent general meeting of the British Astronomical Association in London, England, was enlivened by reminiscences of telescope making experts. Part of this is recounted here, from the BAA *Journal,* Vol. 70, No. 7.

"Dr. F. L. Jackson. – I should like to express one or two warnings. It is very unwise to use coarse carborundum in the bathroom. Make sure other members of the family do not want to take a bath before you do it. The reason is that the mixture of carborundum sludge is second to none for bunging up drains. Don't use it in the kitchen either; it is terrible stuff to eat. The third thing is the encouraging fact that one can become more skilled as time goes on. I have made three mirrors, and the third took only a couple of hours on two afternoons. One should find no difficulty in figuring, and it is better to get a paraboloid if one can.

"Mr. H. Joy. – My wife ground a 6-inch mirror under tuition in a period of eleven hours and a half from start to finish, over a period of four or five weeks. I myself ground a 10-inch mirror, and my record of time showed that it took twenty-one and three-quarter hours, figured right out.

"The President [Dr. H. C. King]. – This gets like telling fishing stories! I once made a mirror in a week-end while my wife was away, doing all the work in a drawing-room and leaving no trails behind – except for a single tell-tale stain of rouge, the cause of subsequent domestic troubles.

"Mr. J. V. Thomson. – Cerium rouge is much better because you can get it off your clothes.

"The President. – When I made 8-inch mirrors I usually started on a Friday evening and had a mirror finished on the Sunday evening."

THREE NEW JUNIOR GROUPS

Formed last April, the Clinton County Astronomy Club now has 10 members. The president is John T. McIntosh, 1400 W. McClurg St., Frankfort, Ind.

Another 10-member organization is the Bishop Gibbons Astronomy Club, which may be contacted by writing Rev. Br. A. E. Newman, 2602 Albany St., Schenectady, N. Y.

The current project of the Cliffside Stellar Research Group is building 8-inch and 6-inch f/7 reflectors. More information about the club is available from Richard Bayer, 509 Lindberg Ave., Cliffside Park, N. J.

ASTRONOMICAL LEAGUE TO MEET IN DETROIT

Papers are now being accepted for this year's general convention of the Astronomical League in Detroit, Michigan, July 1-3. Program-time requests should be sent to E. C. Balch, 96 Farrand, Highland Park 3, Mich.

Convention headquarters will be the Henrose Hotel, near Detroit's new civic center. Information about room rates and registration may be obtained from John Manquen, 1838 Catalpa, Berkley, Mich.

The principal speaker is to be Dr. Helen Sawyer Hogg, David Dunlap Observatory, an eminent authority on star clusters. The chairman of the Detroit Astronomical Society's convention committee is C. D. Marshall, 17396 Westmoreland, Detroit 19, Mich. Amateurs planning to display an exhibit may request space from Edward Fifield, 19376 Montrose, Detroit 35, Mich. In charge of publicity is Joseph Maple, 20116 California, St. Clair Shores, Mich.

ST. JOSEPH, MISSOURI

Twenty amateurs have organized the Midland Empire Astronomical Society. Further information may be had from the secretary, Mrs. Edna Davis, 206-B S. 14th, St. Joseph, Mo.

OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

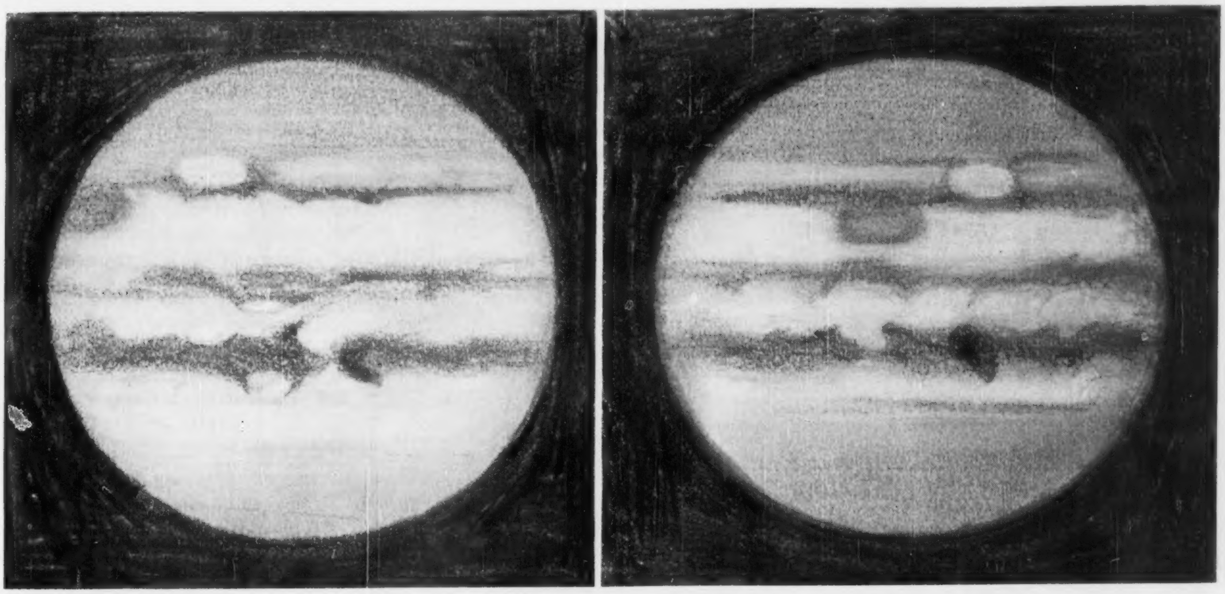
Jupiter's Red Spot in 1960

OBSERVATIONS of the planet Jupiter from England were greatly hindered in 1960 by the planet's southerly declination. Indeed, it never attained an altitude greater than 15° at London. Hence seeing was seldom good. However, I was able to observe on its disk a conjunction of the famous red spot with a large white oval cloud in the south tropical belt (STB).

Various latitude zones of Jupiter rotate at different rates. Two standard rotation periods, therefore, have been worked out, system I for the equatorial zone and its environs, and system II for the rest of the planet, which turns more slowly. By timing the moment a feature crosses the disk's central meridian, the observer can determine its longitude, in system I or II as the case may be.

During several weeks of observation, various features will show gradually increasing or decreasing longitudes, as they move at lesser or greater speed than the standard rotation. At the present time, the red spot is very slowly falling behind system II. On the other hand, the adjoining STB is moving much faster than the red spot.

In the STB were some large white oval clouds, the biggest being a well-defined object almost the size of the red spot, which it was overtaking. In early June, 1960, I first realized that a conjunction would take place between spot and cloud. At that time the oval, 18 degrees of longitude in extent, was gaining on the red spot by this amount every 40 days. It seemed that they would be alongside each other by the end of September.



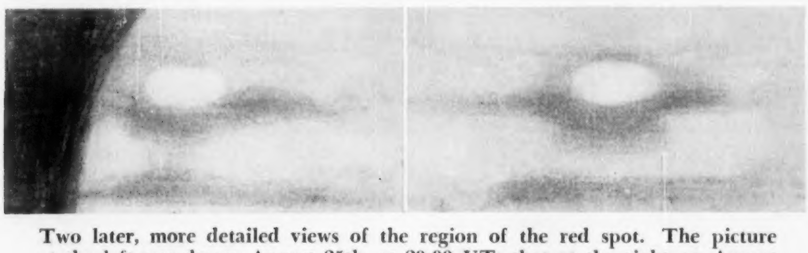
Terence Pearce drew Jupiter at 21:45 UT on July 15, 1960 (left), with a 4½-inch refractor at 135x, and at 22:00 UT July 29th (right), when the red spot was near the planet's central meridian, using a 6-inch reflector at 100x.

However, the closer the two became, the more quickly they drew together. At the same time, the red spot faded considerably, losing contrast and distinctness.

My drawing for July 15th shows the red spot just leaving the left edge of Jupiter's disk. In good seeing, both spot and oval were visible in a 3-inch refractor. The cloud was a beautiful white, while the red spot presented its usual appearance, a fairly well-defined *gray* patch.

By August 27th, when conjunction was imminent, the oval was somewhat less distinct, but the red spot had changed greatly, becoming a washed-out smudge visible only during moments of best seeing. The conjunction probably occurred in the first week of September, but I was unable to witness the event.

The fading of the spot was almost certainly not a mere contrast effect. Perhaps



Two later, more detailed views of the region of the red spot. The picture at the left was drawn August 25th, at 20:00 UT; that at the right on August 27th at 20:30 UT. The oval lies to the south of the spot, which had faded.

the oval brought along some general overlying haze which obscured the spot. That the cloud may have been at a higher level in the planet's atmosphere seems plausible, especially since this cloud encroached upon and hid the darker belts.

My observations of Jupiter had to end in October. Other watchers in more southerly latitudes should have been able to continue work during November and December. They may be able to tell whether the red spot regained some of its earlier conspicuousness. Did the cloud take the spot in tow, or was the latter slowed down or even broken up?

TERENCE PEARCE
22 Mead Crescent
Chingford, London E 4, England

SUNSPOT NUMBERS

The following American sunspot numbers for November have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

November 1, 70; **2,** 69; **3,** 72; **4,** 52; **5,** 69; **6,** 86; **7,** 105; **8,** 121; **9,** 120; **10,** 116; **11,** 137; **12,** 100; **13,** 101; **14,** 97; **15,** 81; **16,** 98; **17,** 83; **18,** 93; **19,** 81; **20,** 86; **21,** 66; **22,** 57; **23,** 34; **24,** 39; **25,** 47; **26,** 53; **27,** 53; **28,** 58; **29,** 51; **30,** 68. Mean for November, 78.8.

Below are provisional mean relative sunspot numbers for December by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

December 1, 74; **2,** 92; **3,** 101; **4,** 96; **5,** 92; **6,** 98; **7,** 94; **8,** 91; **9,** 97; **10,** 103; **11,** 102; **12,** 101; **13,** 92; **14,** 101; **15,** 104; **16,** 99; **17,** 87; **18,** 76; **19,** 70; **20,** 62; **21,** 56; **22,** 35; **23,** 35; **24,** 37; **25,** 57; **26,** 48; **27,** 70; **28,** 86; **29,** 94; **30,** 103; **31,** 130. Mean for December, 83.3.

AN UNUSUAL OCCULTATION

On the evening of November 25-26, 1960, my son and I timed the occultation of the 6.8-magnitude star ZC 3333 by the moon. He was using a 5-inch refractor at 20x, I an 8-inch reflector at about 98x.

Both of us were surprised to see the star vanish, reappear, and vanish again. This sequence took perhaps 0.3 second, the final disappearance occurring at 1:07:32.0 Universal time.

Because the star went behind the extreme northern part of the moon, its path relative to the limb was very oblique, and hence it may have been temporarily covered by a lunar hill.

LEO DEMING
9 N. 6th St.
Terre Haute, Ind.

ED. NOTE: The last two of the eight occultations of Aldebaran visible in the United States during 1960 occurred on December 2nd and 30th. Observations of these two events were reported to Sky and Telescope by S. Pauley, Jr., Greenwood, R. I., and P. Nachman, Chicago, Ill., respectively.

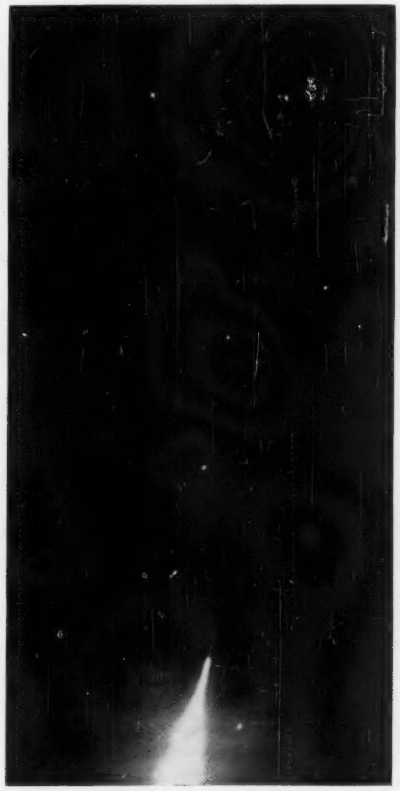
Observations of the Geminid Meteors

DURING my observations of the recent Geminid shower, I was fortunate to photograph a spectacular fireball, on December 14, 1960, at 1:05 a.m. Pacific standard time. It illuminated the northern sky to nearly twilight brightness as it passed behind the 4,000-foot mountains on my northern horizon. The fiery object seemed at least as brilliant as magnitude −5.

Orange and yellow in color, the fireball was visible for three seconds, and left a very distinct blue-white train lasting for 10 seconds.

The photograph was taken under unusual circumstances. I was sighting through the view finder of my 35-mm. Minolta camera, regularly used for meteor photography. Suddenly a brilliant fireball moved into the camera's field, the region of Ursa Major. Luckily the shutter was cocked and my hand was on the cable release!

In the picture the meteor's trail begins between the stars Zeta and Eta Ursae Majoris. It was actually first seen about three degrees below Gamma, but the camera shutter did not open until slightly later.



With his camera's wide-angle lens set for meteor photography and pointed toward the northeast, where the Big Dipper was "standing" on its handle, Norman D. Petersen caught the flare of a very bright meteor on December 14, 1960. Exposed 30 seconds, Tri-X film was developed in Microdol.

My observations of the Geminid meteor shower continued over five nights from December 10th to 15th, for an average of three hours per night. Six bright Geminids were photographed, including the fireball, out of the 278 meteors logged visually. On the night of Geminid maximum, December 12-13, I counted 25, 24, 37, and 46 meteors during successive one-hour intervals beginning at 10 p.m. and ending at 2 a.m.

One of the photographed meteors, which appeared only 43 minutes after the fireball, was of magnitude −2; it also went through Ursa Major and disappeared below the northern horizon.

Observation of the Geminid shower was greatly aided by fine weather conditions. Nighttime temperatures ranged from a warm 62° Fahrenheit on December 11-12 to a low of 42° on December 14-15. The sky was free of clouds on all nights, and I was able to complete most of my observations before the rising of the last-quarter moon.

Others in Southern California who saw the fireball I photographed are asked to contact me, or report to American Meteor Society headquarters, 521 N. Wynnewood Ave., Narberth, Pa.

NORMAN D. PETERSEN
6836A Valmont St.
Tujunga, Calif.

DEEP-SKY WONDERS

HOW close a double star can your telescope split? A simple answer is given by the well-known *Dawes limit,* proposed by the English amateur W. R. Dawes in 1865 from his experience with refractors of up to 8-inch aperture. A double star, consisting of two 6th-magnitude components, can just be separated if the distance between the stars is $4.56/A$ seconds of arc, where A is the telescope aperture in inches. Hence, a 4-inch should be barely able to split a 1.14-second pair, of the kind stated.

The qualifications to Dawes' empirical rule are many. A keen eye, good optics, and first-rate seeing are needed to match its predictions. Equally important, if the components of a double are much brighter or fainter than magnitude 6, or if they differ greatly in brightness, separating the pair will require a larger telescope than the rule indicates.

Studying the work of double star observers who used refractors from 4-inch to 36-inch aperture, T. L. Lewis found that the closest measurable separation is given by the following formulas: $4.8/A$ for a pair of 6th-magnitude stars; $8.5/A$ if they are of the 9th magnitude; $16.5/A$ for doubles whose components differ by three magnitudes; and $36.0/A$ when this difference is as great as six magnitudes. The details are well worth reading in Lewis' paper, published in *Observatory, 37,* 372, 1914.

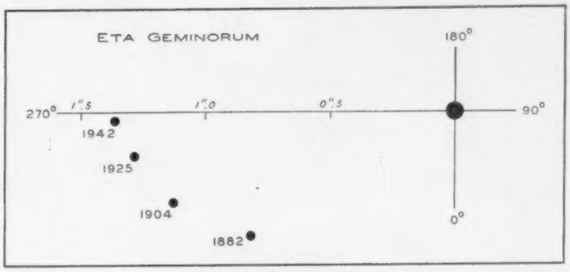
But his study does not fully answer the amateur's needs. What are the rules for reflectors or for small portable refractors, and what performance should a Maksutov give on doubles? The enthusiastic observer will want to find out for himself the capability of his own telescope. For an example of a carefully planned project of this sort, see Harold Peterson's article in SKY AND TELESCOPE for September, 1954, page 396.

Two famous binary stars well placed for viewing in February illustrate how a double is more difficult if its members are very bright or very unequal. Castor (Alpha Geminorum) is one of the great show objects of the sky. With components of magnitudes 2.0 and 2.9, it was an easy object a century ago, when their separation was five seconds of arc. But now the companion is closing in rapidly, as periastron in 1968 is approached. At the present time, the companion is in position angle 161°, distance 1".96.

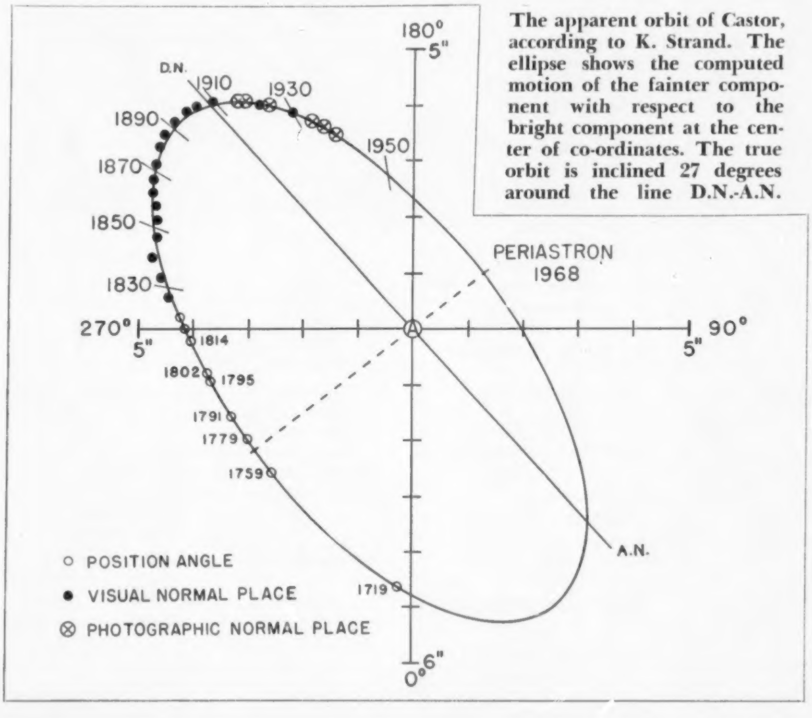
Eta Geminorum is a fine example of an unequal close double. The primary is a 3rd-magnitude red star, somewhat variable in brightness, with a 6th-magnitude secondary 1".4 distant. (The glare of the brighter star makes the other seem much fainter than it actually is.) Lewis' formula calls for a 12-inch aperture to divide this pair, but some measurements have been made with smaller telescopes.

Since S. W. Burnham discovered the companion of Eta Geminorum in 1881, it has traversed only a small portion of its orbit; the period of revolution may be many times greater than Castor's 380 years.

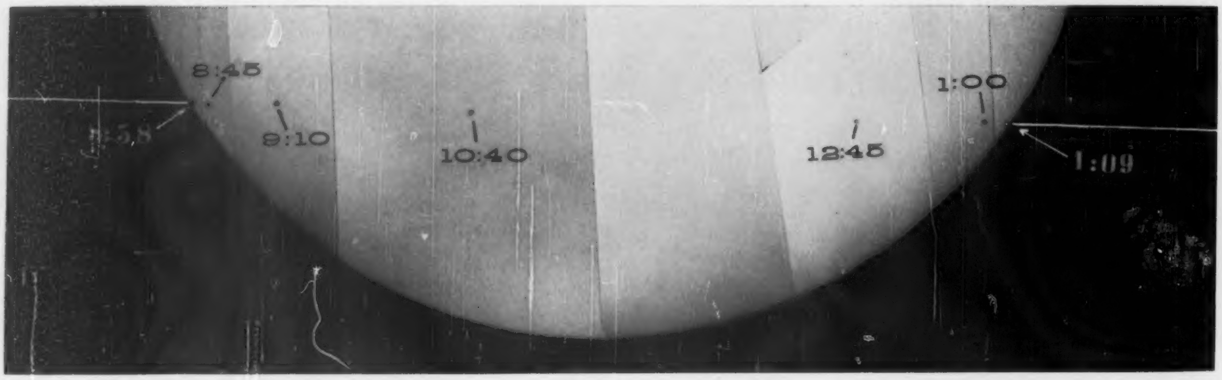
WALTER SCOTT HOUSTON
36 Lawn Ave.
Middletown, Conn.



Some observed positions of the slowly moving faint companion of Eta Geminorum. This pair is still gradually widening. The scale of distances is labeled in seconds of arc. Position angle increases counterclockwise from north.



The apparent orbit of Castor, according to K. Strand. The ellipse shows the computed motion of the fainter component with respect to the bright component at the center of co-ordinates. The true orbit is inclined 27 degrees around the line D.N.-A.N.



Staff members of the Adler Planetarium, Chicago, Illinois, prepared this mosaic of the November 7th transit, marked in Central standard time. The sections were selected from 80 photographs made with an unaluminized 6-inch mirror and Herschel wedge combination, which reduced the sun's light to 0.0004 normal; each exposure was 1/500 second.

MERCURY'S TRANSIT: ADDITIONAL OBSERVATIONS

ON PAGE 16 of last month's issue is an analysis of numerous reports from observers of the passage of Mercury across the sun's disk on November 7, 1960. Several additional observations are collected here.

The first table contains 19 timings of contacts. Successive columns give: key number of observer; the observed Universal time of contact; the corresponding predicted time, from the formulae on page 306 of the 1960 *American Ephemeris;* and the difference between the observed and the computed times. This table was compiled in the same way as the corresponding one in the January issue, where further explanation can be found.

The second table identifies the observers, specifying their geographical location and, if known, the instrument used.

SKY AND TELESCOPE also thanks the Adler Planetarium and Astronomical Museum, Chicago, Ill.; H. Goldgraber, Chicago, Ill.; and E. Vianna, Rio de Janeiro, Brazil, who submitted reports and photographs not previously acknowledged.

J. A.

CONTACT II

No.	*Observed* h m s	*Computed* h m s	*O − C* s
108	14 36 15	14 36 47	−32
109	36 58	36 45	+13
110	36 38	36 45	− 7
111	36 52	36 45	+ 7
112	36 48	36 45	+ 3
113	36 57	36 45	+12
114	36 05	36 44	−39

CONTACT III

No.	*Observed* h m s	*Computed* h m s	*O − C* s
110	19 09 27	19 09 38	−11
112	09 40	09 38	+ 2
114	09 33	09 37	− 4
115	09 52	09 39	+13
116	09 52	09 48	+ 4
117	09 50	09 48	+ 2
118	10 04	10 00	+ 4

CONTACT IV

No.	*Observed* h m s	*Computed* h m s	*O − C* s
109	19 11 27	19 11 39	−12
110	11 09	11 39	−30
113	11 27	11 39	−12
114	11 16	11 38	−22
115	11 24	11 39	−15

No.	*Place*	*Longitude* ° ′	*Latitude* ° ′	*Observer*	*Telescope and Remarks*
108	Port Jefferson, N. Y.	73 03	40 57	A. Butera	6M, with V. and J. Fox
109	Montreal, Que.	73 30	45 30	K. Brasch	
110	Montreal, Que.	73 30	45 30	K. Chalk	
111	Montreal, Que.	73 30	45 30	G. Gaherty, Jr.	
112	Montreal, Que.	73 30	45 30	J. Low	
113	Montreal, Que.	73 30	45 30	C. Papacosmas	
114	Paterson, N. J.	74 12	41 00	P. Del Vecchio	
115	Key Biscayne, Fla.	81 54	25 42	T. Ferris	2½L, 50x and 101x, with C. Goodwin, III
116	Northfield, Minn.	93 09	44 28	R. Althauser	5L, P, Goodsell Obs.
117	Northfield, Minn.	93 09	44 28	J. Perlman	5L, P, Goodsell Obs.
118	Tucson, Ariz.	110 57	32 14	P. Steffey	4½L, 184x, Steward Obs.

Nos. 109 through 113 were taken from the December, 1960, *Skyward,* the monthly publication of the Montreal Centre, Royal Astronomical Society of Canada. Under *Telescope and Remarks,* the first figure is aperture in inches; L, refractor; M, reflector; magnification, or projected image, P.

Here a group of 50 barrel assemblies is being readied for completion by our Mr. Ernest Arndt. Each barrel consists of 23 parts. The largest piece is an aluminum forging with thin walls and a thick bottom. We send groups of the tall cups or shells to a man named Gerald Fegley, who chose to make parts for Questar in his own shop rather than be superintendent in the die shop of a great die-casting firm. With the engine lathe, Mr. Fegley turns off and discards the forging's entire thick bottom, which exists only to leave enough metal on the inside of the tube to permit him to cut big husky threads. After so doing, he shortens the tube and reduces its outside diameter on the lathe. Mr. Fegley then ships these precisely machined-all-over tubes to a painting specialist, who masks off the large internal threads and the cell seat at the opposite end, then sprays the inside with a newly developed nonreflective paint.

Meanwhile, Mr. Fegley takes a disk of the tempered aluminum alloy 24S-T4, and machines it to fit a heavy ring cut from a tube of similar metal whose wall is .5-inch thick. These two parts, held together by 4 stainless-steel screws, form our barrel's rear closure plate. Stronger than steel, each composite plate is threaded to fit one tube. Both are numbered, and we now have a removable tube, held to its closure by large accurate threads we can trust.

A central hole is prepared and accurately receives a ground stainless-steel tube 4 inches long on which our mirror will slide. The tolerance permitted here is only $\pm.0001$. The matching tube, 3 inches long, fits its mate so well that it will pump air without a lubricant. Thus Questars can focus just as easily at $-86°$ as at room temperature.

The last operation at the Fegley shop presses a lens cell into each barrel. The final cuts are not taken on the lens seat until the entire assembly rotates as a unit on the engine lathe with the inner tube running dead true. The numbered cell is then withdrawn and black anodized; the entire set of matching parts is reassembled, tested for total runout, and delivered in individual cases to us.

Having installed a total of 20 light baffles, Mr. Arndt is here checking one assembly for alignment. It is rare for any to be off-center by more than .0008 inch, a quite permissible amount.

What all this means is that your Questar will give you the same perfect diffraction images year after year. You will never have to have it realigned.

STAR-TESTED QUESTARS ARE USUALLY IN STOCK READY FOR IMMEDIATE DELIVERY, FROM $995. TERMS ARE AVAILABLE. LET US SEND YOU THE QUESTAR BOOKLET.

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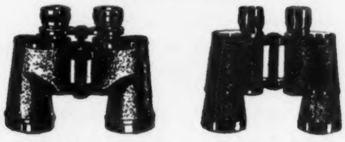

American Type "Zeiss" Type

Complete with carrying case and straps. American type offers a superior one-piece frame and clean design. Individual Focus (IF) or Center Focus (CF).

Cat. No.	Size	Field at 1,000 yards	Type	Price, ppd.
S1149	6 x 15 IF	360 ft.	Opera	$12.75
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S1435	6 x 30 IF	395	"Zeiss"	16.75
S1438	7 x 35 CF	341	"Zeiss"	20.75
S1437	7 x 35 IF	341	"Zeiss"	17.95
S1771	7 x 35 CF	341	American	23.50
S1439	7 x 35 CF	578	American*	35.00
S2191	7 x 50 CF	530	American**	42.50
S1106	7 x 50 CF	372	"Zeiss"	24.95
S-961	7 x 50 IF	372	"Zeiss"	22.50
S1503	7 x 50 CF	372	American	32.50
S1443	8 x 30 CF	393	"Zeiss"	21.00
S1229	8 x 30 IF	393	"Zeiss"	18.25
S1108	10 x 50 IF	275	"Zeiss"	26.75
S1442	20 x 50 CF	183	"Zeiss"	33.75

*Wide-angle 11° **Wide-angle

All prices above plus 10% Federal tax.

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Cat. No. S1580..........20 x 50.......... 20.00 ppd.

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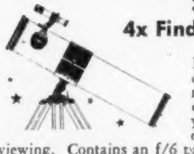
35x — 175x
4x Finder — Wood Tripod



From the mysterious craters of the moon to the fabulous rings of Saturn, this high-quality telescope will give you many pleasurable hours of crystal-clear astronomical viewing. Contains an f/6 parabolic mirror which gives a 50-per-cent brighter image than the ordinary f/10. Two coated eyepieces, 35x and 175x; rack-and-pinion focusing; sun filter; and 4x focusing finder. Its short tube, 27¾" long, and collapsible wood tripod (33" closed, 60" open), make for portability, stability, and compactness. Finished in white enamel with black trim. Imported. Shipping weight about 20 lbs.

FREE BOOK with Scope: **DISCOVER THE STARS.**

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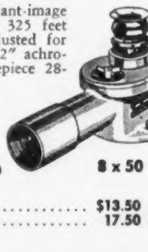
8-Power Elbow Telescope

This telescope has a brilliant-image 48° apparent field; actually 325 feet at 1,000 yards. Can be adjusted for focusing 15 feet to infinity. 2" achromatic objective, focusing eyepiece 28-mm. f.l., Amici erecting system. Turret-mounted filters: clear, red, amber, and neutral. Lamp housing to illuminate reticle for night use. Truly the biggest bargain you were ever offered. Original Gov't. cost $200.



8 x 50

Cat. No. S1686 Not Coated .... $13.50 ppd.
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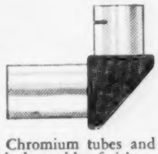
A Beginner's Guide to the Skies

R. Newton Mayall and Margaret W. Mayall

"Probably the best handbook now available for a newcomer to amateur astronomy." — *Sky and Telescope.* Contains a wealth of information about the solar system, and many lists of objects to be observed with binoculars or a telescope; includes 100 pages of detailed charts and observing data, arranged alphabetically by constellation. 184 pages. Cloth bound.

Cat. No. S2301 .... $2.50 ppd.

Star Diagonals



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Will accommodate finder above. Made of cast aluminum with black crackle finish. Each ring has three locking wing screws for adjusting. Base has two holes for mounting screws, fits any diameter tubing. Easy to mount. Inside diameter of ring mount 1-15/16".

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Coated **80-mm. Objective**

Big 80-mm.-diam. (3⅛") objective, for spotting or astronomical use. Will show stars of the 11th magnitude — 100 times fainter than the faintest visible to the naked eye. Table-top tripod included, extended 18", closed 13¼". Length of scope 16¼". Combined weight of scope and tripod is 5¼ lbs. All coated optics.

FIVE EYEPIECES

Power	Field at 1,000 yards	Exit pupil diam.	Relative brightness
15x	122 ft.	5.4 mm.	29
20	122	4.0	16
30	61	2.7	7
40	49	2.0	4
60	32	1.3	1

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60-mm.-diam. Scope. Same as above but with smaller objective. Equipped with same five eyepieces — 15x, 20x, 30x, 40x, 60x. Coated. With tripod.

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The buy of a lifetime at a great saving. First choice of the amateur and professional astronomer. Perfect lenses set in black anodized standard 1¼" O.D. aluminum mounts.

Cat. No.	F.L.	Type	ppd.
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S1851	6 mm. (¼")	Ramsden	4.75
S1853	12.5 mm. (½")	Ramsden	4.50
S1207	12.5 mm. (½")	Symmetrical	6.00
S1251	16 mm. (⅝")	Erfle (wide-angle)	12.50
S1257	16 mm. (⅝")	Orthoscopic	12.50
S1209	18 mm. (¾")	Symmetrical	6.00
S1211	22 mm. (27/32")	Kellner	6.00
S1835	27 mm. (1-1/16")	Kellner	4.50
S1355	32 mm. (1¼")	Plossl	12.50
S1253	35 mm. (1⅜")	Symmetrical	8.00
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COATED LENSES 75 cents extra.

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Coated Lenses

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● **FREE RUBBER EYESHIELD** ●
With S1405

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ADAPTER PLATE AND TUBE. Aluminum tapered tube and adapter plate, black anodized and finished in black crackle. Slides into our 5" O.D. Aluminum Tubing No. S1511. These parts are used with the eyepieces above to make a Rich-Field Telescope. Details in our catalogue.

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Cat. No. S1020 ....$13.50 ppd.
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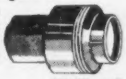

This mounted eyepiece has two magnesium-fluoride-coated achromatic lenses 29 mm. in diameter. Excellent definition. E.F.L. 1¼". Cell fits 1¼" tubing.

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Here is a wonderful opportunity for you to own a most mechanically perfect Rack-&-Pinion Focusing Eyepiece Mount with variable tension and adjustment. Will accommodate a standard 1¼" eyepiece, positive or negative. The body casting is made of lightweight aluminum with black-crackle paint finish, focusing tube of chrome-plated brass. Focusing tube for refractors has a travel of 4", for reflectors 2", and will fit all size tubing.

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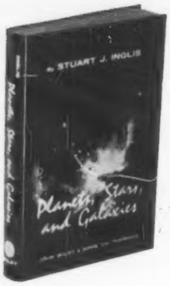
Presenting astronomy for  *the space-age reader . . .*

PLANETS, STARS & GALAXIES

By STUART J. INGLIS, *Instructor in Astronomy and Physics, Contra Costa College, San Pablo, California*

This new book is intended to introduce astronomy to those who, although lacking a detailed background in mathematics and science, want to gain an understanding of the physical universe. *Planets, Stars, and Galaxies* has been specifically designed to stimulate and maintain the reader's interest; yet in every detail it is scientifically accurate.

Presents astronomy step by step

Rather than being broken into arbitrary sections and sub-sections in the "classical" manner, the book moves logically and coherently from paragraph to paragraph, chapter to chapter — developing each new topic from those preceding. Also, the various aspects of astronomical science are clearly related to one another.

Covers important concepts and theories to encourage speculation

Knowing that people interested in astronomy can't help using their imagination in wondering about the universe, the author provides both the information and encouragement which lead to *intelligent* speculation. The first eight chapters deal with the methods and tools of astronomical observation and with the solar system. The second half begins with a discussion of the sun and then proceeds to consider stars, nebulae, galaxies, and the universe as a whole.

Gives important ideas and theories of astronomers

Of course the book sets forth the observations astronomers have made of the universe, but this is only a starting point. Also presented are the theories and ideas that astronomers have advanced on the age, origin, and evolution of the universe as a whole and the celestial objects it contains. In short, with *Planets, Stars, and Galaxies,* the reader expands his thinking beyond the confines of history and the geologic time scale, to appreciate the size and vastness of space.

Special features

- Completely up to date, including important developments in radio astronomy and rocket and satellite research
- Contains a wealth of illustrations, with clear star charts and a detailed map of the moon
- Although mainly descriptive, the book stresses mathematical aspects of astronomy in the discussion of binary stars
- Wherever possible, the relationship of astronomy to other studies is shown

CHAPTER HEADINGS

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Planetary Motions
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Minor Planets, Meteors and Comets
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The Evolution of Stars
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CLOSE BINARY SYSTEMS

By ZDENEK KOPAL

University of Manchester

How photometric and spectroscopic observations are induced to give up all their information about components of close binary systems. Also gives an account of our general knowledge of close binary systems and their significance within the framework of stellar evolution. 1959. 558 pages. $16.75

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BOOKS AND THE SKY

A MANUAL OF SPHERICAL AND PRACTICAL ASTRONOMY

William Chauvenet. Dover Publications, Inc., New York, 1960. Vol. I, 708 pages; Vol. II, 631 pages. $2.75 per volume, paper bound.

LONG out of print and hard to buy secondhand, William Chauvenet's *Manual* has remained famous as a storehouse of information on precise astronomical measurements. Because his book is once again easily available, some indication of its special nature will be useful to many.

When first published in 1863, the *Manual* gave a complete, modern summary of the art of observational astronomy (apart from its purely descriptive aspects). It furnished detailed explanations of the use of refined astronomical instruments, and full instructions for reducing observations made to determine time, geographical location, and positions of celestial objects. Widely studied as an advanced textbook, the treatise reached a fifth edition by 1891 without general revision.

Several major revolutions have occurred in practical astronomy during the century since Chauvenet wrote. Visual observation techniques have been largely supplanted by photographic methods, which provide more accurate, easier, and cheaper means to catalogue stars, determine stellar distances, and obtain comet and asteroid positions. New instruments, such as the prismatic astrolabe, photographic zenith tube, and improved double-image micrometers, have been introduced. Radio time signals have made obsolete a host of Chauvenet's methods for determining geographical longitudes. Desk calculating machines and large computers require formulae in a form different from that most convenient a century ago, when all reductions were made with logarithms.

Chauvenet's *Manual* is thus hopelessly outdated as a systematic treatise. However, there are some isolated parts that remain of great value. In Vol. I the introductory chapter on astronomical coordinate systems retains usefulness as a reference. In the second volume there are valuable sections on the filar micrometer and zenith telescope, two types of astronomical equipment that are still standard tools.

Also worth while today is the detailed account of the marine sextant and the determination of its instrumental errors. Much of this can be applied by users of the more modern bubble sextant. For many years, however, navigational tables have supplanted the old formulae given by Chauvenet for converting observed altitudes into a geographical position.

Although no longer employed by professional astronomers, a ring micrometer is a very serviceable accessory for the amateur, allowing him to determine simply the approximate right ascension and declination of a celestial object. Easy to make and use, the ring micrometer is particularly suited for telescopes that do not have clock drives or equatorial mountings. Chauvenet gives a comprehensive account of it in pages 436 to 449 of his second volume.

There is still a good deal of salvage in Chauvenet for the modern astronomer who is willing to clear a way through its thick underbrush of equations. Those with a taste for the history of science will find the *Manual* an important survey of observational astronomy a century ago, in the age of the heliometer and meridian circle.

J. A.

THE MOON

Franklyn M. Branley. Thomas Y. Crowell Co., New York, 1960. 114 pages. $3.50.

NOT OFTEN does one find a book designed for readers with no previous knowledge of astronomy that is clear, easy to read, and free from the errors and distortions that frequently creep into such popular presentations. Franklyn Branley's *The Moon* is a good book of this type. Intended for junior high or early high school students, it

simply and lucidly discusses the physical nature and motions of the moon.

The treatment throughout is scientifically sound and well thought out. All technical terms are defined when introduced, making it possible to explain clearly even such subjects as the different kinds of lunar libration. However, the book is not a text. Only two algebraic formulas, for a sphere's volume and the law of gravitation, are introduced. But even a person with no knowledge of algebra can profit from reading the discussions where these formulas are used.

The more important chapter headings are "Motions of the Moon," "Why the Moon Stays in Orbit," "Eclipses," "The Moon's Surface," "Temperatures on the Moon," "The Atmosphere of the Moon," "Mass and Density of the Moon," and "Tides – Then and Now." Considerable space is devoted to lunar motions and to such topics as sidereal and synodic periods, and hunter's and harvest moons.

The book is up to date. In the discussion of a possible lunar atmosphere, the work of N. Kozyrev and of D. Alter in connection with the crater Alphonsus is noted, and a Soviet photograph of the other side of the moon is included.

Of interest is the lunar map that presents photographs of the first- and last-quarter moon on a grid. A table of surface features is keyed to the photograph, enabling the reader to locate any feature in a few moments yet eliminating printing of names directly on the pictures.

Defects in the volume are minor. The sketches on pages 8 and 9 intended to illustrate the moon illusion are not successful. Many illustrations have no captions, and this leads to some confusion. For example, the nice photograph of Baily's beads on page 41 should be labeled as such. A picture of the solar corona could have been added, as well as a list of future solar eclipses in the United States, to supplement the table of lunar eclipses.

The Moon does very well in its intention – to present a brief account of the earth's natural satellite in a simple yet authoritative manner.

WILLIAM H. GLENN
Amateur Astronomers Association
New York 24, N. Y.

STARBOUND

Eileen and **Raymond Schussler.** G. P. Putnam's Sons, New York, 1960. 160 pages. $2.95.

FOR TEENAGERS and for adults with a newly acquired interest in astronomy and rocketry, *Starbound* is an intriguing history of man's attempts to leave mother earth. In the past, many ways were proposed or pretended for travel to other worlds. For instance, a team of swans took Domingo Gonzales to the moon where he met intelligent beings, in Francis Godwin's novel of 1638!

Since then, we have discovered that outer space is empty, and that the moon lacks air and water. Newton propounded his laws of motion, and gradually knowledge grew of the universe.

Prior to World War II, R. H. Goddard in the United States and an astronautical club in Germany launched the first liquid-fueled rockets. Before long the Germans developed the awesome V-2, a rocket that traveled over 5,000 miles per hour and attained a height of 60 miles before hitting a target 200 miles away. This was a major technological breakthrough. Finally, with the first artificial satellite on October 4, 1957, the space age began in earnest.

Mr. and Mrs. Schussler present a good picture of current developments in space travel. There are outlines of the American projects Mercury and Dyna-Soar. A few short-range predictions of the uses of satellites and space bases, of the probable results of lunar and planetary expeditions, and of "you as a space cadet" are fanciful yet plausible.

A simple vocabulary and good printing make this short book easy to read. Though the up-to-the-minute outlook of *Starbound* will before long put it out of date, its account of past and present happenings makes it doubly fascinating for the general reader. It should whet many young appetites for more information about the rapidly expanding field of space science.

JOHN GARDNER
The Principia
St. Louis, Mo.

Sam Houston College's vibration-free Tinsley telescope

Sam Houston State Teachers College, Huntsville, Texas, needed a telescope primarily for visual and photographic instruction of undergraduate astronomy classes. □ A custom-made Tinsley telescope was chosen for two simple reasons: 1) there is no more responsive, reliable telescope made; 2) its massive size and rigidity assure crisp, sharp images—in spite of the fact that it is housed in a rooftop observatory on a busy science building. □ When the Sam Houston 16" Newtonian-Cassegrain reflector is set properly, it remains accurately set. □ Large, pre-loaded tapered cone bearings on both axes provide effortless control of the instrument. It is powerful, too. Total effective focal length is 256 inches. □ There is no limit to the photographic research Sam Houston students can perform with this telescope. Its versatile Baker Photographic Corrector permits photography of a seven-degree field. □ The Sam Houston telescope—like all custom instruments from Tinsley—was designed to meet the client's special needs. If you are faced with a problem such as rooftop mounting, Tinsley can help you solve it. Please address your inquiries to Department C. Tinsley Laboratories, Inc., 2526 Grove Street, Berkeley, Calif.

TINSLEY
LABORATORIES, INC.

PLANET EARTH FILM SERIES

A series of 13 motion pictures on findings from the International Geophysical Year was recently completed by the National Academy of Sciences. Entitled Planet Earth, the 16-mm. films run 27 minutes each and are available in either black-and-white or color.

Seven films are concerned with the upper atmosphere and the earth's surroundings: Our Nearest Star (the sun and solar activity), The Flaming Sky (aurorae), Magnetic Force (the earth's magnetic field), Radio Waves (including the ionosphere and radio astronomy), Cosmic Rays, Research by Rockets, and Science in Space (satellite and space-probe research). The remaining movies are devoted to geodesy, seismology, the earth's gravity, meteorology, glaciology, and oceanography.

McGraw-Hill Text-Films, 330 W. 42nd St., New York 36, N. Y., has been given the distribution rights. The price of each film is $80.00 for black-and-white, $150.00 for color.

NEW BOOKS RECEIVED

CONCEPTS OF SPACE, *Max Jammer*, 1960, *Harper*. 208 pages. $1.40, paper bound.

The historical development of ideas about space is traced from Aristotle through Newton to the modern influences of non-Euclidean geometry and relativity. This volume by an Israeli philosopher is a revision of a book first published in 1954.

ASTRONOMY, *H. C. King*, 1960, *Franklin Watts, Inc.*, 575 Lexington Ave., New York 22, N. Y. 256 pages. $4.95.

Aspects of astronomy from instruments to galaxies are presented in this layman's introduction. Some 200 photographs and drawings illustrate the text, which has a 10-page glossary of astronomical terms.

RUSSIA'S ROCKETS AND MISSILES, *Albert Parry*, 1960, *Doubleday*. 382 pages. $4.95.

A well-informed popular history of Russian rocketry leads from 19th-century anticipations to space probes. Both scientific and military applications are described from Soviet press material.

AUSSERGALAKTISCHE STERNSYSTEME UND STRUKTUR DER WELT IM GROSSEN, *Heinrich Vogt*, 1960, *Akademische Verlagsgesellschaft Geest und Portig K.-G.*, Sternwartenstr. 8, Leipzig C 1, East Germany. 147 pages. DM 20.

External Galaxies and the Structure of the Universe is a Heidelberg astronomer's summary of modern knowledge about galaxies, clusters of galaxies, and intergalactic matter. There are extensive accounts of the red shift and of galaxies as radio sources. The second half of this German-language volume consists of a survey of modern cosmological theories. There are 113 references in the bibliography.

EL HOMBRE ANTE EL UNIVERSO, *Francisco Aniceto Lugo*, 1960, *Exclusivas Ferma*, Union 28, Barcelona, Spain. 545 pages. 160 pesetas.

This thick book in the Spanish language is a detailed popular introduction to astronomy, illustrated with a standard selection of photographs of large telescopes and impressive celestial objects. The author's ex-

planations are lucid and easy to read, and he covers almost every phase of the subject. The reader should consider cautiously, however, those parts where Dr. Lugo presents his personal and often rather unorthodox views about life on other worlds.

THE STORY OF GEOLOGY, *Jerome Wyckoff*, 1960, *Golden*. 177 pages. $4.95.

Numerous highly colored drawings and photographic reproductions illustrate this popular introduction to geology, which tells about the origin and constantly changing character of rocks and the earth's mountains, water courses, and seas.

THE AMATEUR SCIENTIST, *C. L. Stong*, 1960, *Simon and Schuster*. 584 pages. $5.95.

From the column of the same name in *Scientific American* magazine comes this collection of experiments and diversions in all fields of science, including archaeology, rocketry, nuclear physics, and mathematics. The astronomical projects include a transistorized telescope drive, a universal sundial, and three-dimensional photography of the moon.

OUTER SPACE PHOTOGRAPHY FOR THE AMATEUR, *Henry E. Paul*, 1960, *Amphoto*. 124 pages. $2.50.

A well-known amateur expert discusses the instruments and methods of astronomical photography. Specific information on lenses, films, and exposure times is given for many subjects — from meteors to nebulae. Pictures taken by amateur astronomers illustrate the text.

THE AUTOBIOGRAPHY OF SCIENCE, *Forest Ray Moulton* and *Justus J. Schifferes*, editors, 1960, *Doubleday*. 748 pages. $5.95.

The history of science, from the creation of man as given in *Genesis* to the Tass announcement of the first Sputnik, is illustrated by over 150 short nontechnical selections from original sources. The authors of the astronomy excerpts are Archimedes, Copernicus, Galileo, Halley, and O. Struve. This book is a revision and enlargement of the 1945 first edition.

APPLIED OPTICS AND OPTICAL DESIGN, PART TWO, *A. E. Conrady*, 1960, *Dover*. 323 pages. $2.95, paper bound.

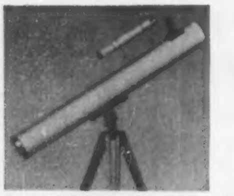
The 1957 Dover edition of *Applied Optics and Optical Design* contained only the 10 chapters completed by A. E. Conrady before his death in 1944. Now Rudolf Kingslake has assembled and edited chapters 11 to 20 from the author's notes. Intended for the advanced optical designer, Part Two covers such topics as optical tolerances, microscope objectives, and telephoto lenses. Many ingenious mathematical methods are presented, dating from before the application of high-speed computers to design problems.

THE SKY AND ITS MYSTERIES, *Ernest Agar Beet*, 1960, *Dover*. 238 pages. $3.00.

In this work originally published in 1952, a British teacher presents a popular summary of astronomy, with emphasis on the solar system. References at the end of each illustrated chapter invite further study by the newcomer to astronomy.

THE WIDER UNIVERSE, *Paul Couderc*, 1960, *Harper*. 128 pages. $2.25.

This slender volume, translated from the French by Martin Davidson, is the fourth in Harper's Science Today series. The author, an astronomer at Paris Observatory, reviews concisely the established facts about the Milky Way and other galaxies.



3-inch Astronomical Reflector

60 to 180 Power
An Unusual Buy!

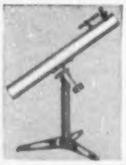
Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with locks on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60x eyepiece and a mounted Barlow lens, giving you 60 to 180 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

FREE with Scope: Valuable STAR CHART plus 272-page "HANDBOOK OF THE HEAVENS" plus the book "HOW TO USE YOUR TELESCOPE."

Stock #85,050-Y........................$29.95 ppd.

4¼" ASTRONOMICAL TELESCOPE

UP TO 255 POWER
New Vibration-Free Metal Pedestal Mount



With this scope you can see everything described above, but with greater power. Also, it will split closer double stars. Mirror has twice the light-gathering power. Rack-and-pinion focusing, real equatorial mounting — only one motion needed to follow the stars! Aluminum tube. 6-power finder telescope. 2 standard-size eyepieces and mounted Barlow lens give you powers of 40x, 90x, 120x, and 255x. Low-cost accessory eyepiece available for higher powers. **FREE** with Scope: Valuable **STAR CHART** plus 272-page **"HANDBOOK OF THE HEAVENS"** plus the book **"HOW TO USE YOUR TELESCOPE."** Shipping wt. 25 lbs.

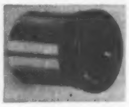
Stock #85,105-Y....................$79.50 f.o.b.
Barrington, N. J.

Same telescope as described above but equipped with Electric Clock Drive.

Stock #85,107-Y....................$109.00 f.o.b.
Barrington, N. J.

NOW! A FULL SELECTION OF ORTHOSCOPIC EYEPIECES

Wide, flat field — better correction under high magnification — excellent eye relief.



The orthoscopic eyepiece is one of the most important and best corrected eyepieces for astronomical work. These are of a four-element design, with coated lenses, and are standard 1¼" outer diameter, precision made of chrome-plated brass and aluminum.

Stock #30,364-Y	4 mm.	**$14.50 ppd.**
Stock #30,404-Y	6 mm.	**14.50 ppd.**
Stock #30,405-Y	12.5 mm.	**14.50 ppd.**
Stock #30,406-Y	18 mm.	**14.50 ppd.**
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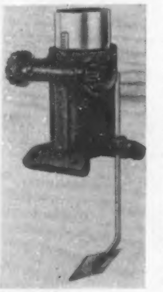
Rack-&-Pinion Eyepiece Mounts



Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment. Lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes, respectively.

For Reflectors

Stock #50,077-Y..(less diagonal holder)....$8.50 ppd.
Stock #60,049-Y..(diagonal holder only).... 1.00 ppd.

For Refractors

Stock #50,103-Y..(for 2⅞" I.D. tubing)....12.95 ppd.
Stock #50,108-Y..(for 3⅞" I.D. tubing)....13.95 ppd.

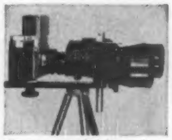
FLASHLIGHT POINTER for Movie Screens

Ideal for pointing out interesting features on movie and slide projection screens. Excellent lecture tool. For teacher use on maps, etc. Flashlight focuses an arrow where you point it.

Stock #60,117-Y.........$9.50 ppd.

BINOCULAR-TO-CAMERA HOLDER

For Exciting Telephoto Shots
Will fit any camera

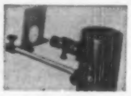


Bring distant objects 7 times nearer with a 35-mm. camera, 7 x 50 binocular, and our BINOCULAR-TO-CAMERA HOLDER. Ideal for photographing constellations, star clusters, the moon, as well as cloud formations, wildlife, vistas. Camera and binocular attach easily. Use any binocular or monocular — any camera, still or movie. Take color or black-and-white. Attractive gray crinkle and bright chrome finish, 10" long. Full directions for making telephoto pictures included.

Stock #70,223-Y........................$11.50 ppd.

Take Pictures Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES

Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!



SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

All for the low, low price of $9.95

Includes brackets, 28¾" rod, projection screen, screws, and directions. Aluminum; brackets black crinkle painted.

Stock #70,162-Y........................$9.95 ppd.

PRISM STAR DIAGONAL

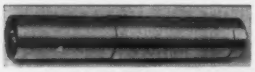
For comfortable viewing of stars near the zenith or high overhead with refracting telescopes using standard-size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent high-quality aluminized right-angle prism. The tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path length of the system is about 3½".

Stock #70,077-Y........................$12.00 ppd.

AMICI-PRISM STAR DIAGONAL

Same as above except contains Amici roof prism instead of usual right-angle prism. Thus your image is correct as to top-bottom, making it excellent for terrestrial viewing.

Stock #50,247-Y........................$12.00 ppd.



NOW! LENS ERECTOR FOR TERRESTRIAL VIEWING WITH YOUR REFLECTOR

This Edmund development adds real convenience to viewing objects on the earth. Just put the lens erector in your eyepiece holder, insert eyepiece, and focus normally. You see everything right side up and correct as to left and right. Made of polished chrome-finish brass telescoping tubing that will fit any standard 1¼" eyepiece holder. Tubing is 9½" long and slides 3" into eyepiece holder. Erecting system consists of two coated achromats.

Stock #50,276-Y........................$9.95 ppd.

STAR TIME CALCULATOR

This handy slide rule automatically makes the conversion from star or sidereal time to standard time. Saves the amateur astronomer the time and trouble of calculations. Size: 10⅓" x 3⅜"; plastic-coated cardboard.

Stock #40,399-Y........................$1.50 ppd.

"MAKE YOUR OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes; polished and aluminized, with lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y........................$16.25 ppd.

OFFSPRING OF SCIENCE . . . REALLY BEAUTIFUL!

CIRCULAR DIFFRACTION-GRATING JEWELRY

A Dazzling Rainbow of Color!

Shimmering rainbows of gemlike color in jewelry of exquisite beauty — made with CIRCULAR DIFFRACTION-GRATING REPLICAS. Just as a prism breaks up light into its full range of individual colors, so does the diffraction grating. Promises to become a rage in current fashion. 1" diam.

Stock #30,349-Y	Earrings	**$2.75 ppd.**
Stock #30,350-Y	Cuff Links	**$2.75 ppd.**
Stock #30,372-Y	Pendant	**$2.75 ppd.**
Stock #30,390-Y	Tie Clasp	**$2.75 ppd.**

WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner eyepiece, type 3. Two achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y........................$7.95 ppd.

6X FINDER TELESCOPE

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 2 holders each with 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

Stock #50,121-Y........................$8.00 ppd.

STANDARD 1¼" EYEPIECE HOLDER

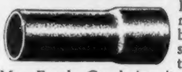
Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y.........$2.50 ppd.

Stock #60,049-Y
Diagonal holder........$1.00 ppd.

EDMUND SCIENTIFIC CO.

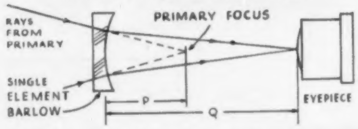
THE ORIGINAL GOODWIN RESOLVING POWER BARLOW



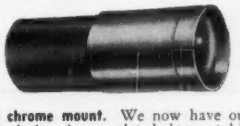
For many years, this achromatic coated Barlow lens has been the pride and joy of serious astronomers. Due to the death of the designer, Mr. Frank Goodwin, it has not been available for the past two years. NOW we can offer these lenses, in exact accordance with the original specifications. Remember, this Barlow is achromatic, coated, mounted in a blackened tube, and as optically perfect as only precision craftsmen can make it. Complete with instructions, in a 4"-long adapter tube for standard 1¼" eyepieces.

Stock #60,122-Y........................**$23.50 ppd.**

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing, with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Barlow lens is nonachromatic.

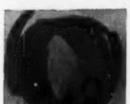
Stock #30,200-Y...Mounted Barlow lens....**$8.00 ppd.**

UNMOUNTED 3X BARLOW LENS

These lenses are made for telescopes that have smaller-diameter eyepieces than the standard 1¼" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length —1-5/16", unmounted.

Stock #30,185-Y....0.932" diam...........**$3.50 ppd.**
Stock #30,328-Y....0.912" diam...........**$2.50 ppd.**

3X ADJUSTABLE-DIAMETER BARLOW LENS



For telescopes with eyepieces smaller than the standard 1¼" outer-diameter size. Prongs on mount can be opened or closed to fit tubes from 13/16" to 1" inner diameter. Directions for using included.

Stock #30,339-Y......**$5.00 ppd.**

MORE POWER FROM YOUR JAPANESE TELESCOPE

Mounted Barlow for Japanese Telescopes

By inserting this single-element lens in the eyepiece end of your Japanese telescope, and putting your regular eyepiece in the end of the Barlow tube, you can increase your telescope's power up to three times. Thus, instead of 60x, you will get 120x or 180x. Barlow is mounted in two pieces of telescoping brass tubing each 4" long, satin chrome plated on the outside. Inner diameter of large tube and outer diameter of small tube are 0.965", the standard size for most Japanese telescopes. Measure yours before ordering. 0.965" is approximately 31/32" or 24.5 mm.

Stock #30,370-Y..........................**$6.00 ppd.**

SPECIAL! VARIABLE 10- TO 20-POWER U. S. ARMY OBSERVATION TELESCOPE

This is the most versatile and complete government - surplus telescope unit we have ever offered you. USES: spotting scope, surveying, balloon and satellite tracking, all general observation. *THE TELESCOPE:* Elbow-type, 10 to 20 power continuously variable. Field of view 6° 9' to 3° 5'. 2¼" objective lens. Focusing eyepiece. *THE MOUNTING:* This is really something! Has completely enclosed 8"-diam. circle scale reading directly to 1/10 mil or approx. 20 seconds. (6400 mils equal 360°.) Clutch release allows rapid rotation. Rotates 90° horizontal to vertical with direct reading to 1 mil. Has crossed levels, precision adjustment, and many other exciting features. *THE TRIPOD:* Made of solid oak with brass fittings. Has cast brass head with four leveling screws. Legs adjustable from 30" to 52" excluding mount height. Extremely sturdy and rigidly cross braced. Instruments used but in good condition. Shipping wt. approx. 100 lbs.

Stock #85,117-Y............**$89.50** f.o.b. Chicago

CLOCK-DRIVEN EQUATORIAL MOUNT ON PEDESTAL BASE IDEAL FOR YOUR 6" OR 8" REFLECTOR

Accurate electric clock drive and heavy-duty mounting. Operates on household current. Follows stars smoothly. Pedestal is 24" high. Polar-axis shaft diameter 1".

Stock #85,111-Y...........**$74.50** f.o.b. Barrington, N. J.

Same mount and clock drive on 32" hardwood tripod.

Stock #85,081-Y...........**$69.00** f.o.b. Barrington, N. J.

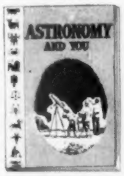
Same mount on metal pedestal, no clock drive.

Stock #85,108-Y...........**$45.00** f.o.b. Barrington, N. J.

Same mount on tripod, no clock drive.

Stock #85,023-Y........**$39.50** f.o.b. Barrington, N. J.

FREE! "Astronomy and You"



New booklet in comic-book style tells about astronomy from historic times to the present, also covers telescopes and telescope making. Free, on request, with your order. Also available in quantity to astronomy groups for star parties, meetings, to museums, planetariums or school groups. Refer to this *Sky and Telescope* ad in writing us.

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y.....¼" focal length.....**$4.75 ppd.**
Stock #30,203-Y.....½" focal length.....**$4.50 ppd.**

NEW! SCIENCE FAIR PROJECT KITS

Edmund kits are carefully planned to give any boy or girl the fun and excitement of discovering science facts. Such carefully planned projects can lead the student to awards or scholarships. Adults too will find them an excellent introduction to the various fields of science.

For Junior High School and beyond:

MOLECULE AND CRYSTAL MODELS KIT — Rods and balls to make atomic models, plus directions.

Stock #30,413-Y......................**$2.50 ppd.**

NUMBER-SYSTEMS ABACUS — Makes a dramatic exhibit demonstrating number systems other than decimal system.

Stock #70,334-Y......................**$4.25 ppd.**

SOIL TESTING KIT — Basis for many fascinating experiments regarding growth of plants, etc.

Stock #60,118-Y......................**$2.00 ppd.**

TOPOLOGY — All the ingredients for a project on 4-color map problems. Moebius strips, etc.

Stock #70,353-Y......................**$6.00 ppd.**

CRYSTAL-GROWING KIT — Grow breathtaking displays of large crystals with this set.

Stock #70,336-Y......................**$9.50 ppd.**

For Age 8 through Junior High School:

MAGNETISM KIT — Based on magnetism demonstrations developed by UNESCO.

Stock #70,325-Y......................**$3.75 ppd.**

COLOR THROUGH POLARIZATION — Show the beautiful color effects produced by passing polarized light through transparent objects.

Stock #70,350-Y......................**$2.00 ppd.**

OPTICAL ILLUSION KIT — Diagrams, lenses, mirrors, etc., for producing many amazing optical illusions.

Stock #70,352-Y......................**$3.00 ppd.**

GIANT ERFLE EYEPIECE 1½" F.L.

War-Surplus Bargain — Gov't. Cost Approx. $100

Large telescopes should have one of these for low-power viewing. Apparent field of view 65°. Also use with our 24"-focal-length Aerial Camera lens to make a 16-power wide-field telescope or a 27-power scope with one of our 40"-focal-length Aerial Camera lenses. Low-reflection-coated, 5-element lens system. Field lens of Eastman Kodak's rare-earth glass for better aberration correction. Has diopter scale. Smooth focusing, ⅜" movement. Outside diameter of attaching threads, 3" — 32 threads per inch. Clear aperture of eye lens 2", field lens 1-25/32". Weight 3½ lbs.

Stock #50,091-Y..........................**$9.95 ppd.**

ADAPT GIANT ERFLE TO STANDARD TELESCOPE EYEPIECE SIZE

This adapter lets you use our Giant Erfle with any telescope having a standard 1¼"-diam. eyepiece holder.

Stock #50,358-Y..........................**$3.95 ppd.**

FREE CATALOG "Y"

144 Pages! Over 1000 Bargains!

Fantastic variety — rarely before have so many lenses, prisms, optical instruments, and components been offered from one source. Probably the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Many science and math learning and teaching aids.
Write for Free Catalog "Y".

ORDER BY STOCK NUMBER . . . SEND CHECK OR MONEY ORDER . . . SATISFACTION GUARANTEED!

BARRINGTON • NEW JERSEY

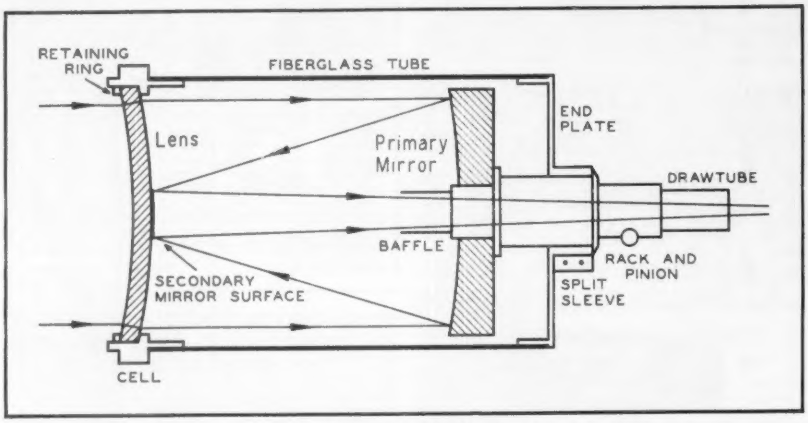
GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

An 8-inch Catadioptric of Superb Observing Qualities

IT SEEMS to me that Newtonian reflectors and long-focus refractors are out of date, for I have had extraordinary observing success with my 8-inch f/16 Gregory-Maksutov, whose optics were made by John Gregory himself. With seeing of 7 on a scale of 1-10, powers exceeding 600 have been employed with good results, and on rare occasions I have used 800x without the image breaking down.

As the pictures show, the telescope's main tube is very stubby. It is made of fiberglass 9.8" in diameter and 18" long, finished in aqua-blue. The correcting lens is held by a cast-aluminum cell which is bonded to the tube, a retaining ring on the cell's outer face allowing easy removal of the lens for cleaning. There is a dewcap, fabricated from the same material as the main tube. The 54-mm. finder has a giant Erfle eyepiece with

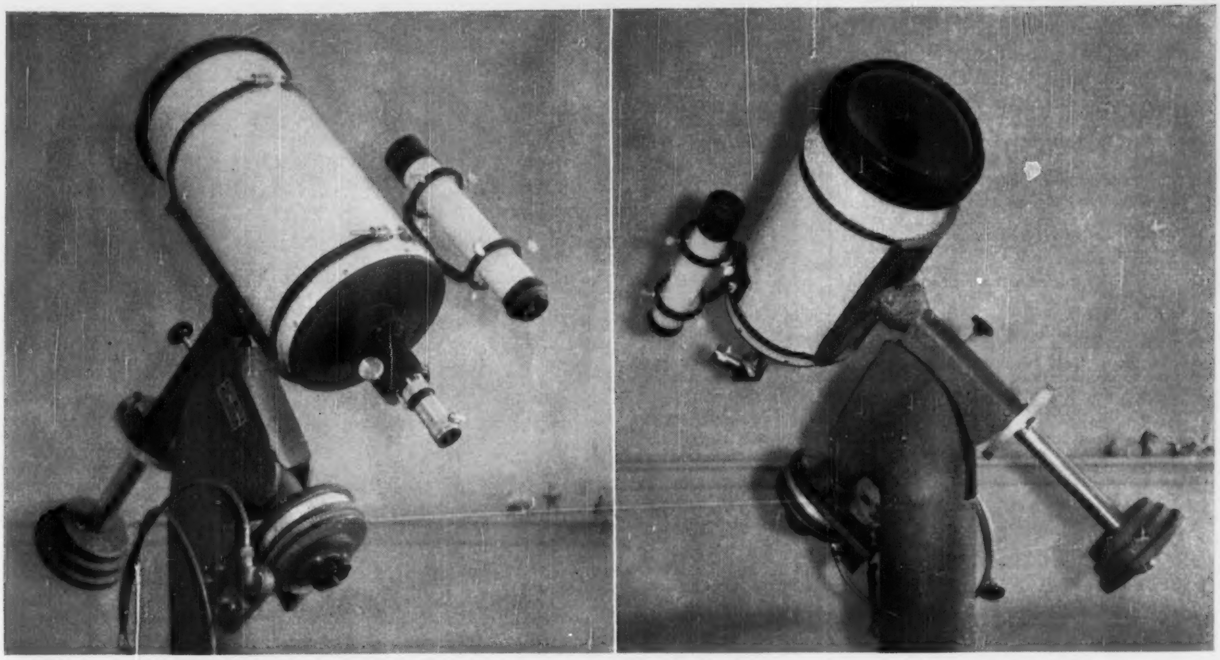


A schematic view of Sol Saul's 8-inch catadioptric telescope.

crosshairs. The weight of the tube, finder, and attached components is 24 pounds, all supported on a very heavy mounting with an electric drive. Because of the short tube length, there are no observable image tremors, even in a 40-mile wind!

With an instrument of this type, great care must be taken in designing and constructing the tube assembly, to insure that the parts remain perfectly collimated at all times. Yet in my design provision has even been made to move the primary mirror longitudinally in order to change the focus for viewing terrestrial objects not at optical infinity. This is done by supporting the mirror on a spindle that passes through a machined end plate. The mirror may be shifted back and forth by loosening the split-sleeve boss on the end plate.

Thus, the separation of the correcting lens and the mirror can be varied, and there is no necessity for long extension tubes behind the mirror. When used for terrestrial observing, provision must be made to reduce fogging of the field of view caused by light reaching the eyepiece directly from the scene. As in the usual Cassegrainian arrangement, a long baffle tube is inserted (inside the eyepiece drawtube) and extended through the mirror to the very edge of the incoming cone of light. The rack-and-pinion device is bolted on one end of the spindle, so that eyepieces and attachments other than those of the standard 1¼" outside



The author's pictures show his 8-inch Gregory-Maksutov telescope on an equatorial mounting made by Coast Instrument, Inc. In the right-hand view the concave shape of the correcting lens can be seen.

diameter can be used with the telescope.

To get the best results out of a Maksutov telescope, the finest eyepieces should be obtained. At low power, Kellners seem satisfactory, but for medium and high powers orthoscopic oculars are essential. For lunar and planetary studies I usually employ about 250x to 400x. Terrestrially, I have resolved birds nesting in trees two miles away. For observing the sun, I hope to purchase a large solar filter.

Catadioptric performance is breathtaking, and every time I observe it seems a new experience. The moon is an inspiring sight, hundreds of craterlets stand-

ing out; its image is so free of chromatic aberration that the eye tries to invent some. I have seen at least five craterlets within Plato, in spite of the relatively poor observing conditions in this locality. Jupiter shows seven distinct bands, often with further detail when seeing is good. I believe I have seen the disks of Ganymede and Callisto, and possibly some faint detail. Saturn is unusually beautiful, while nebulae and clusters leave little to be desired. On double stars, the Dawes limit of resolution is easily achieved.

SOL SAUL
3 Theodore Dr.
Plainview, N. Y.

An Attachment for Eyepiece-Projection Photography

Although the 6-inch Gregory-Maksutov described in this department last June is my favorite for visual observing, the 12½-inch reflector mentioned at the end of that article is very suitable for projection photography, where its sizable aperture is advantageous. Large-scale shots of the moon and planets can be obtained, as well as photographs of the brighter nebulae and galaxies.

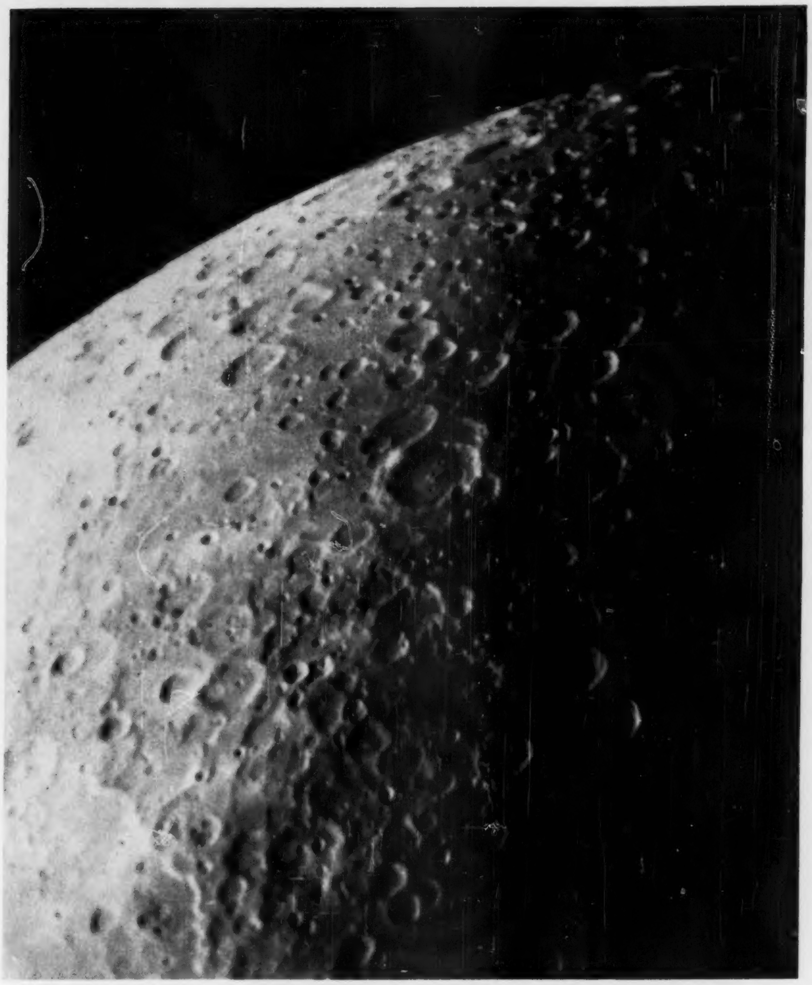
I first tried several different camera attachments that fasten directly to the eyepiece holder, but too much weight was hanging on too flimsy a base for good

The parts of the camera, with the Graphic back and plateholder at the right. The 6" extension tube is at upper right, and in the center is the short tubing that required three sets of threads, and which holds the rack and pinion. The small tube, below the shutter assembly, screws on the front of the latter and fits into the telescope adapter. Photos by the author.

results. The pictures show the construction of my adapter, which has proven quite satisfactory and yet has required a minimum of machine work and expense. Composed of a large shutter, extension tube, and plateholder, it fastens directly to the telescope tube in place of the regular eyepiece mount, the two being readily exchanged by loosening a single thumbscrew. This holds either one to a fixed base in correct alignment with the optical system.

An inexpensive rack and pinion, its end turned off to fit the base adapter on the large tube, was mounted inside a short piece of tubing. The only tricky machin-

The camera mounted at the Newtonian focus of the 12½-inch reflector.



The crater-pocked southwestern portion of the moon, seven days past new, was recorded by Gordon Konstanzer on Ansco Super Hypan film. The ½-second exposure was developed for 15 minutes in X500, and shows practically no grain.

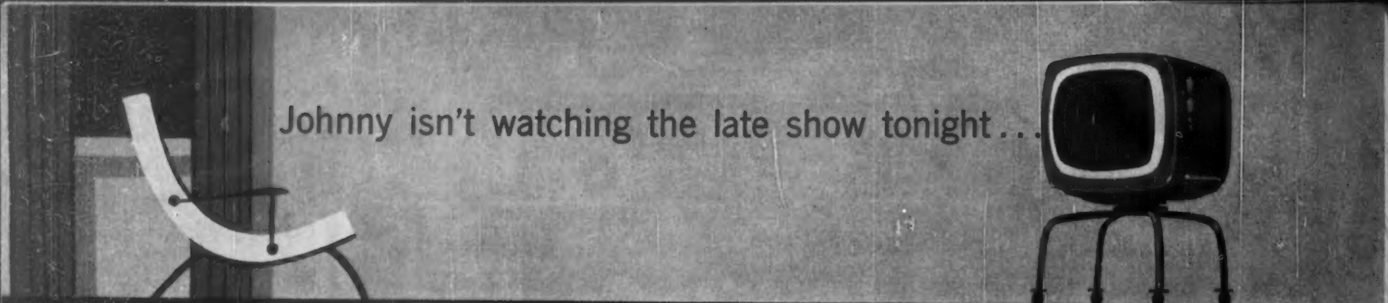
ing was on this last part. It had to be threaded internally to take the rack and pinion, threaded on one outside end to fit the large camera shutter, and threaded externally at the other end to fit the extension tube. The pinion shaft to be used for focusing was extended through the side of this tube.

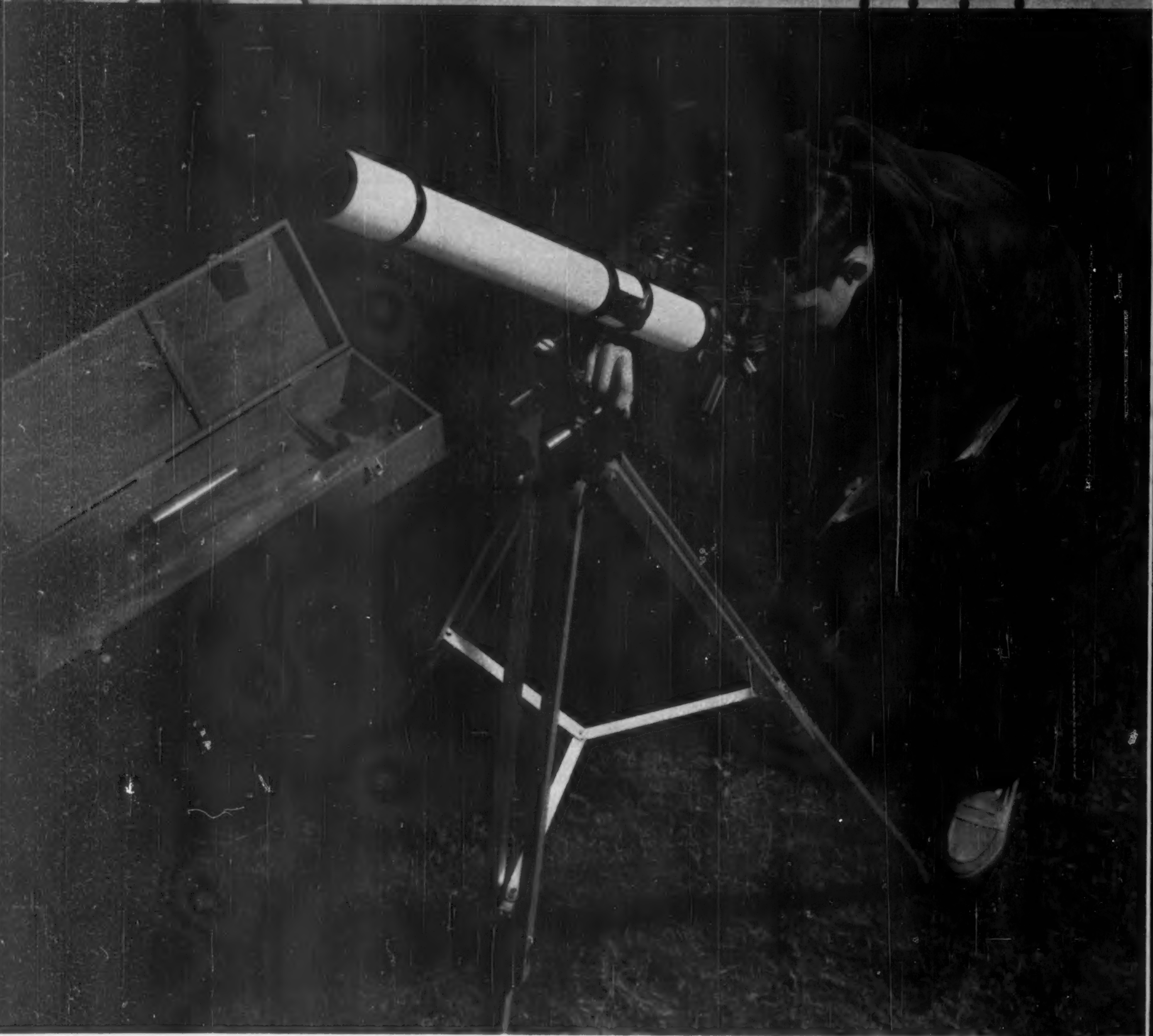
The extension tube has a diameter of 3½" and can be any convenient length, mine being about 6" long. Different magnifications or plate scales are obtained by changing eyepieces, as the extension tube is fixed in length. Another less convenient method would be to use extension tubes of various lengths and only one eyepiece.

The secondhand shutter has a clear aperture of 1⅜". The convenient 2¼-by-3¼" Graphic camera back is spring equipped, to allow the plateholder to be inserted without removing the ground-glass screen. Hence the latter cannot be misplaced.

With the 6" extension tube and a 12-mm. Brandon ocular, the 12½-inch telescope is operated at an effective focal ratio of f/66, yielding an image of the moon close to 7½" in diameter. Less than half of this is covered on the 3¼" dimension of the negative, but the recorded detail in lunar features is fine.

GORDON KONSTANZER
2735 Milan Court
Los Angeles 41, Calif.





The shadows that shiver and shake on the TV screen are shivering and shaking in somebody else's living room tonight. Johnny has discovered something new.

He's traded the fleeting, flickering "thrills" of the 24 inch screen for the timeless excitement and majesty of the night sky.

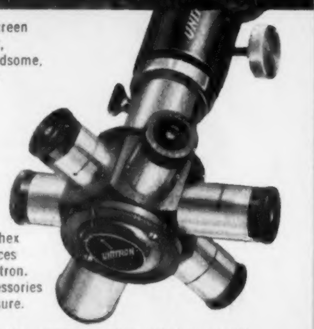
He's traded the nervous rattle of the private eye's gun for a ringside seat at the stupendous nightly fireworks in the heavens.

He has, in short, discovered astronomy.

Nothing better could happen than what happened to Johnny. And it happened simply because someone took the trouble to awaken, nourish and satisfy a lifetime of curiosity in Johnny by making him the gift of a fine telescope.

Someone, not so long ago, gave Johnny a Unitron.

Johnny abandoned his 24" screen for this 2.4" Unitron refractor, complete with its handy, handsome, easily portable carrying case.



This is a close-up of the Unihex Johnny is using. It's 6 eyepieces in one, an exclusive with Unitron. One of a complete line of accessories to multiply your viewing pleasure.

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CELESTIAL CALENDAR

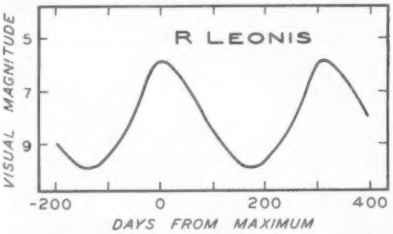
Universal time (UT) is used unless otherwise noted.

R LEONIS

SOME evening this month, look about 6° west of Regulus for the famous variable star R Leonis. It will be easily recognizable in a finder or binoculars, as it forms a compact, characteristic configuration with 18 Leonis (magnitude 5.8), a half-degree northwest, and 19 Leonis (6.4) between them, but considerably closer to R. All three stars are labeled in Norton's *Star Atlas*, but in the revised Skalnate Pleso atlas the name 19 Leonis is inadvertently given to another star several degrees away.

Scheduled maximum of R Leonis comes around February 1st this year, when the variable will probably be about as bright as its neighbor 18. The cycle of light changes runs its course in 313 days, on the average, six months being taken in fading from magnitude 6 to 10, and nearly five months for recovery.

The variability of R Leonis was recognized as early as 1782 by J. A. Koch, a German physician-astronomer who observed at Danzig. In recent years, the brightness oscillations have taken place



This mean light curve for R Leonis was derived from observations made by members of the American Association of Variable Star Observers.

with unusual regularity for a Mira-type variable. However, R. Prager's analysis of the first 150 years of observations shows that once R Leonis brightened to magnitude 4.4, and that minima as faint as 11.6 have occurred.

This is a very red star, its color being especially striking in larger telescopes. The 1950 co-ordinates are right ascension $9^h\ 44^m.9$, declination $+11°\ 40'$.

MINIMA OF ALGOL

February 1, 12:28; 4, 9:18; 7, 6:07; 10, 2:56; 12, 23:46; 15, 20:35; 18, 17:25; 21, 14:14; 24, 11:04; 27, 7:53.

March 2, 4:42; 5, 1:32; 7, 22:21; 10, 19:10.

These minima predictions for Algol are based on a recent timing by D. Engelkemeir, and an assumed period of 2.8674 days. The times given are geocentric; they can be compared directly with observed times of least brightness.

MINOR PLANET PREDICTIONS

No ephemerides are available for this month. The "first four" – Ceres, Pallas, Juno, and Vesta – are all too close to the sun to be observed in February.

VARIABLE STAR MAXIMA

February 1, R Leonis, 094211, 5.8; 1, V Bootis, 142539, 7.9; 2, RU Sagittarii, 195**142**, 7.2; 4, R Canum Venaticorum, 134440a, 7.7; 9, V Coronae Borealis, 154639, 7.5; 17, V Ophiuchi, 162**112**, 7.5; 18, R Aquarii, 233**815**, 6.5; 19, R Carinae, 092**962**, 4.6; 20, S Hydrae, 084803, 7.8; 28, RS Scorpii, 164**844**, 7.0.

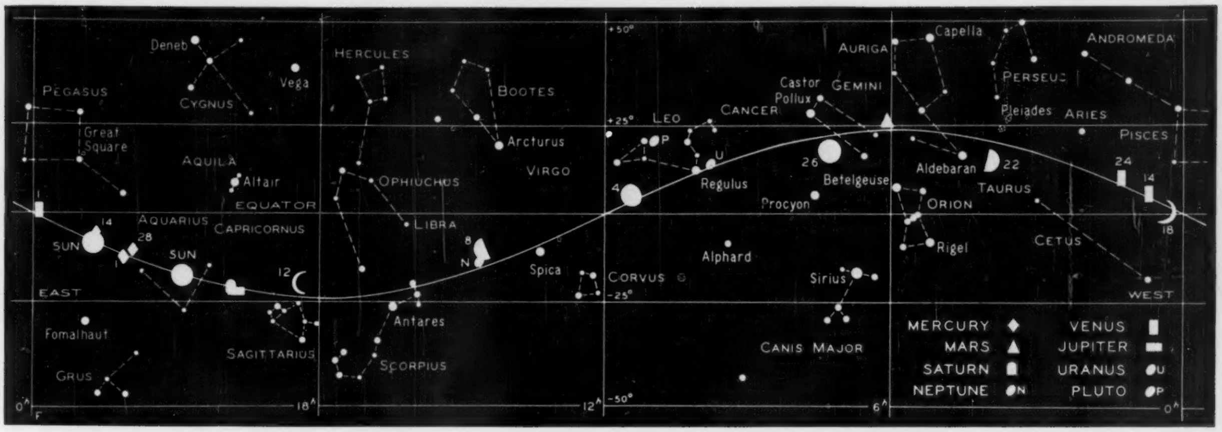
March 1, RT Cygni, 194048, 7.3; 4, R Leporis, 045**514**, 6.8; 5, R Hydrae, 132**422**, 4.5; 7, T Normae, 153**654**, 7.4; 8, R Corvi, 121**418**, 7.5; 9, T Centauri, 133**633**, 5.5.

These predictions of variable star maxima are by the AAVSO. Stars are listed only if brighter than magnitude 8.0 at an average maximum. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for their maxima. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted visual magnitude.

MOON PHASES AND DISTANCES

Last quarter	February	8, 16:50
New moon	February	15, 8:11
First quarter	February	22, 8:35
Full moon	March	2, 13:35

February	Distance	Diameter
Perigee 14, 11^h	222,600 mi.	33′ 22″
Apogee 26, 21^h	252,200 mi.	29′ 27″
March		
Perigee 14, 18^h	225,300 mi.	32′ 58″



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

The sun on February 15th will be totally eclipsed for viewers in a narrow strip across western Europe, the Balkans, and the Soviet Union. As explained in more detail on page 24 last month, totality lasts a maximum of two minutes and 45 seconds over the Sea of Azov. Partial eclipse will be observed over most of Eurasia and a large part of Africa.

Mercury is advantageously placed for observation during the first two weeks of the month, reaching eastern elongation 18° from the sun on the 6th. At that date for nearly $1\frac{1}{2}$ hours after sunset, Mercury may be seen low in the southwest as a reddish object of magnitude -0.4. In the latter half of February, it rapidly moves into the solar glare. Inferior conjunction will occur on the 22nd, when the planet passes into the morning sky.

Venus, in Pisces, is of magnitude -4.2 on February 15th. It sets four hours after the sun and thus dominates the western sky in the early evening. Telescopically, in the middle of the month Venus will be seen as a thick crescent, its disk 42-percent illuminated and 30″ in diameter.

Mars is conspicuous in western Gemini, crossing the meridian about $3\frac{1}{4}$ hours after sunset on the 6th. On this date the -0.3-magnitude planet is stationary in right ascension, changing from westward to eastward motion. Mars appears in telescopes as a reddish disk, 12″.5 in diameter on February 1st and 9″.6 on the 28th.

Jupiter and **Saturn** together will afford a rare and beautiful observing experience before sunrise on February 18th. For the past few months, Jupiter has been approaching Saturn in the sky, and conjunction will occur at 15^h Universal time on that morning in the Western Hemisphere. To the naked eye, the planets will appear as a double star whose components are separated by about 0°.2, brighter Jupiter, magnitude -1.5, being south of Saturn, magnitude $+0.8$. Through binoculars the view should be most impressive. During the rest of the year these planets will continue close to each other, always remaining less than 7° apart.

Conjunctions of Jupiter and Saturn occur only every 20 years or so. The last, a series of three, was in 1940-41, and the next will not be until 1980.

Uranus rises about sunset and is visible all night, for it stands opposite the sun on February 12th. Binoculars will show it as a star of magnitude 5.7, a telescope being needed to reveal the 3″.9-diameter disk. On the 12th, the 1950 co-ordinates are right ascension $9^h\ 44^m.8$, declination $+14°\ 22'$, these changing $-0^m.2$ and $+1'$ per day, respectively. The planet remains all month within the Sickle of the constellation Leo.

Neptune crosses the meridian about two hours before sunrise, and is thus well placed in the southeastern sky for morning observation with small telescopes. On February 12th the greenish 8th-magnitude planet becomes stationary in right ascension at $14^h\ 37^m.2$, declination $-13°\ 29'$ (1950 co-ordinates), then taking up a very slow westerly motion among the stars of Libra.

Pluto, in Leo, reaches opposition to the sun on February 25th, at right ascension $10^h\ 54^m.5$, declination $+21°\ 12'$ (1950 co-ordinates). This 15th-magnitude object is visible in large telescopes.

WILLIAM H. GLENN

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.

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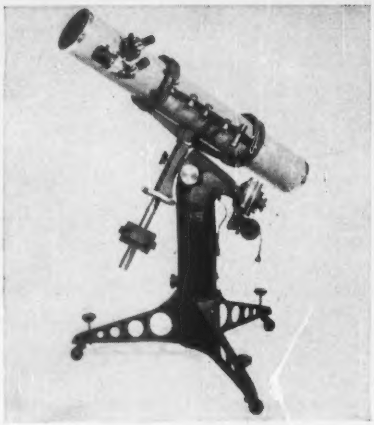

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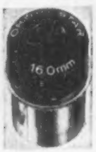

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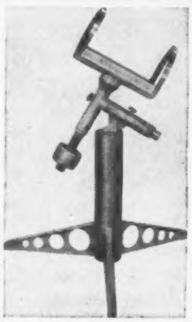

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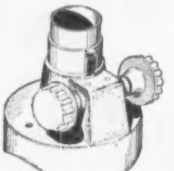

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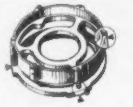

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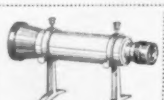

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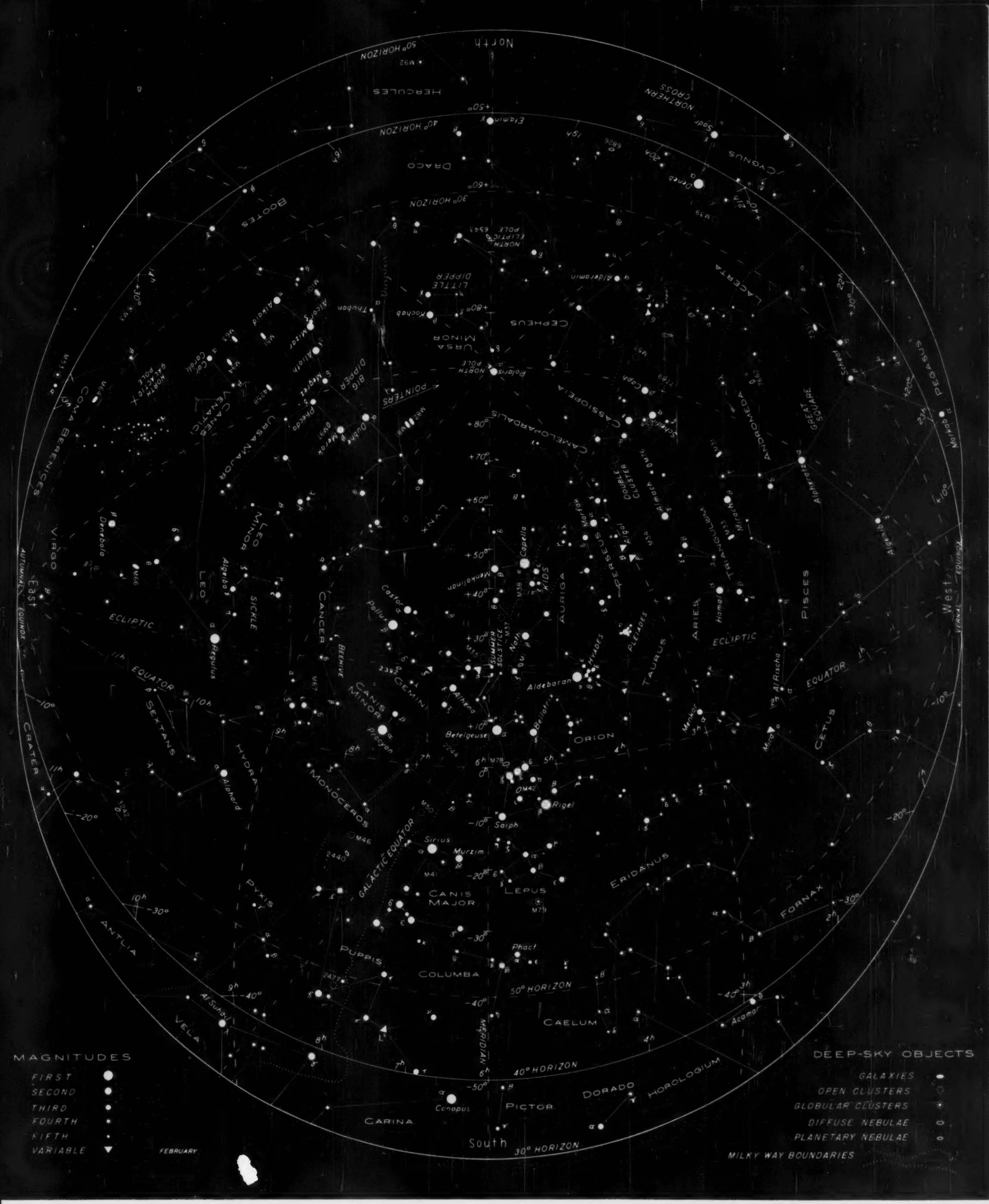

STARS FOR FEBRUARY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 5th and 20th of February, respectively; also at 7 p.m. and 6 p.m. on March 7th and 23rd. For other dates, add or subtract ½ hour per week.

The strikingly brilliant constellation Orion is personified in the Hindu classics as a stag pursuing his own daughter, the star we call Aldebaran. His unnatural chase provoked a three-starred arrow – the belt – from the bow of the hunter hero, Sirius.

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$265 Complete Shipping Weight 80 lbs.	$475 Complete Shipping Weight 150 lbs.	$385 Complete Shipping Weight 145 lbs.	$595 Complete Shipping Weight 185 lbs.	$895 Complete Shipping Weight 245 lbs.	$1,265 Complete Shipping Weight 300 lbs.	$4,200 up Equipped To Your Specifications
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FAN LETTER TO UNITRON...

from a man who DOESN'T own one . . .

HORACE MANN JUNIOR HIGH
P.O. BOX 458
BRANDON, FLORIDA

Dear Sirs,

This letter is both a belated thank you note for your prompt attention to my last order and an order for another item. In my last order I was in a hurry for an item, and asked for a rush order. I was amazed at how soon even UNITRON processed my order. I have noticed that you take pride in your customer satisfaction, so I decided to compliment you also.

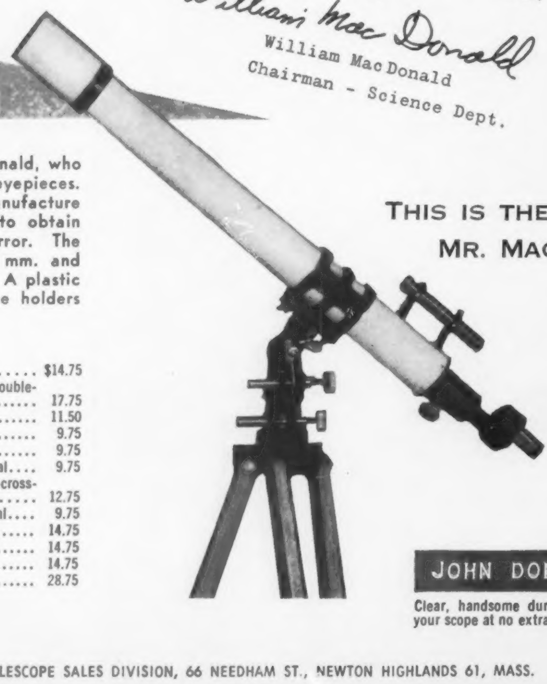
This will probably be one of your more unusual testimonials, because I do not even own a UNITRON. That's right. Our science club was saving up to buy a 2.4-inch UNITRON when a local resident offered to donate to the club a four-inch refractor which he had purchased from another manufacturer. Well, it wasn't UNITRON, but our small club could hardly afford to look this gift horse in the mouth. However, the telescope had no accessories. Our telescope was valued at about $600 so we wanted nothing but the best to fully equip it. This is where UNITRON came in.

We now have a UNITRON equipped telescope, which is the next best thing to a UNITRON telescope. The additional eyepieces that we ordered made a world of difference in viewing. They were far superior to those that came with our telescope. Now, we are ready to purchase a sun projecting screen. Again we are coming to you. We have learned that when you buy UNITRON, you buy peace of mind. Please mail us a projection attachment for our four-inch refractor, and bill me for the amount. Thank you very much.

Sincerely,

William Mac Donald

William Mac Donald
Chairman - Science Dept.



"We wanted nothing but the best," says Mr. MacDonald, who chose from this superb array of coated UNITRON eyepieces. Exclusive optical design and painstaking care in manufacture explain why a UNITRON eyepiece will allow you to obtain maximum performance from your objective or mirror. The following eyepieces, with the exception of the 40 mm. and 60 mm., have outside diameters of 24.5 mm. (.97"). A plastic adapter bushing is available for 1¼" O.D. eyepiece holders at an additional cost of 35¢.

40 mm. Monochro (1¼" O.D.)	$14.75
40 mm. — as above, with double-crossline	17.75
25 mm. Ramsden	11.50
18 mm. Kellner	9.75
12.5 mm. Kellner	9.75
9 mm. Achromatized Symmetrical	9.75
9 mm. — as above, with double-crossline	12.75
7 mm. Achromatized Symmetrical	9.75
6 mm. Orthoscopic	14.75
5 mm. Orthoscopic	14.75
4 mm. Orthoscopic	14.75
60 mm. Kellner	28.75

THIS IS THE UNITRON THAT MR. MACDONALD DIDN'T BUY

UNITRON 2.4" ALTAZIMUTH REFRACTOR, MODEL 114. Mr. MacDonald could have bought the UNITRON 2.4" Refractor, complete with altazimuth mounting and slow motion controls for both altitude and azimuth, 5X 16 mm viewfinder, standard rack and pinion mechanism, 4 eyepieces, choice of UNIHEX or star diagonal and erecting prism system, sunglass, dewcap, dustcap, wooden cabinets, and instructions . . . and all for just **$125.00**

JOHN DOE **Now, you can order a UNITRON with your name on it!**

Clear, handsome durable embossed plastic plate "personalizes" your scope at no extra charge.

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See pages 120 and 121.